ELEMENTS

OF

CHEMISTRY,

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CULTURE, INSCRIPTIONS, AND
BELLES LETTRES.

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CONTENTS.

PART III.

CONCERNING METALLIC SUBSTANCES.

━━━━ ━━━━ ━━━━

PART IV.

CONCERNING VEGETABLE SUBSTANCES.

SECTION I.

SECTION II.

SECTION III.

CONTENTS.

PART V.

CONCERNING ANIMAL SUBSTANCES.

PART THE THIRD.

Concerning Metallic Substances.

INTRODUCTION.

METALLIC substances are distinguished from all the other productions of our globe, by an absolute opacity, a much greater specific gravity than that of any other substance, and a degree of brilliancy peculiar to bodies of this class.

The multiplicity of uses to which metals are applied in the arts, and in medicine, as well as the place which they occupy in the natural history of our planet, render the study of them both interesting and necessary.

1. One of the distinctive characters of metals is their opacity. The most opaque stone, divided into very thin laminæ, becomes transparent; whereas the thinnest plate of metal preserves the same opacity as the mass itself.* This truly characteristic property has induced artists to employ metals to reflect the images of objects. A thin co-

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* Gold excepted; which when beaten into leaf of about the two hundred and eighty thousandth part of an inch in thickness, transmits light of a beautiful green colour. It is highly probable that other metals would become transparent if they could be mechanically divided, or beaten out into laminæ of sufficient thinness, or if artists had sufficient motives to attempt it.

See Newton on Light and Colours, for the proofs on which he grounds his general inference—that all bodies are transparent when sufficiently divided. T.

vering of tin and mercury fixed on the surface of a glass, forms a mirror or looking-glass; and well-polished steel constitutes the mirrors of telescopes.*   The hardness of a metal contributes singularly to facilitate the reflection of objects, as it renders it capable of taking a very fine polish, but its colour must necessarily concur to render it perfect; for these tinges cause it to absorb a greater or less quantity of the rays.   The great defect of metallic mirrors is, that their surface becomes tarnished by the in-evitable alteration which the action of the air and moisture must produce.

2. The relative weight is likewise a character by which we may distinguish a metallic substance.   A cubic foot (French) of marble weighs 190 pounds (livres); a cubic foot of tin weighs 510; and a cubic foot of gold 1348.

The metals, in general, likewise possess the facility of being extended and flattened when struck, or subjected to a strong and gradual pressure: this property is known by the name of Ductility.   All the metals do not possess this quality; but those which possess the metallic qualities most eminently, exhibit this likewise.   We may distin-guish three states of ductility relative to the manner in which it is modified by various known processes.   1. Ductility under the hammer. 2. Ductility through the plate of the wire-drawer.   3. Ductility between the laminating rollers.

Metals ductile under the hammer present themselves in the following order: Gold, Silver, Copper, Iron, Tin, and Lead.

Metals ductile through the wire-drawer's plate form the following series: Gold, Iron, Copper, Silver, Tin, and Lead.—As, in the operation of wire-drawing, the metal is strongly drawn, to cause it to pass through holes of vari-ous diameters, and to reduce it into threads, the metals do

* I do not find that steel has ever been in general use for reflecting telescopes, though it has doubtless been tried among the many expe-riments made for the improvement of these instruments.   A kind of bell-metal, consisting of one-third tin, and two-thirds copper, is com-monly employed for this purpose : the addition of about a fiftieth part of arsenic singularly contributes to the closeness of its grain. On this subject consult the Treatise of Mr. Edwards, annexed to the Nautical Almanac for 1787.   T.

not resist this prodigious extension but in proportion to their greater or less tenacity. Mr. De Fourcroy has therefore distinguished this ductility from the foregoing, by attributing it merely to the tenacity of the metals.

There are some metals which are not ductile either under the hammer or through the wire-drawer's plate, but become very considerably so when an equal and gradual pressure is applied. Zinc is of this nature. Mr. Sage has reduced it into very thin and very flexible leaves, by passing it between the laminating cylinders. *

Heat assists the ductility of all metals, by separating their integrant parts, and forming spaces or interstices which permit the compressed molecules to flatten and extend themselves. This circumstance has induced artists to avail themselves of the assistance of heat in the working of metals. Without this precaution they would either become hard, or crack ; because the particles, being too near each other would be no longer capable of giving way under the hammer.

The ductility of metals permits us to fashion them as we think fit ; and it is upon this admirable property that almost all the arts are founded which relate to the working of metals. Without this property, metallic bodies would consist either of shapeless masses, or large pieces of such figures as casting might produce. But we should be deprived of the number of various objects which the arts have successively afforded to supply our wants or luxuries.

Nature very seldom presents us with metals possessed of the degrees of perfection here enumerated. She has concealed them in the bowels of the earth, combined with various substances ; which, by masking or changing the metallic properties, have left to the industry of man the laborious task of extracting them, clearing them of their original combinations, and giving them the valuable qualities which are peculiar to metals. The metals, thus buried and concealed, form ores. These ores usually exist in clefts or crevices of rocks, which are distinguished by the name of Veins. These veins are more or less in-

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* Zinc is a malleable metal, at a temperature between 210° and 300° of Fahrenheit's thermometer—*Am. Ed.*

clined to the horizon; and the degrees of inclination have
caused them to be distinguished by the names of direct,
oblique, inclined, or level veins, according to the angle
they make with the horizon.   The part of the rock which
rests upon the superior part of the vein, is called the
Roof; and that part upon which the vein itself rests, is
called the Bed of the vein.   These veins are of various
breadths, and are accordingly distinguished by the names
of Slips or Veins.

They possess a greater or less degree of continuity, ac-
cording to which they are distinguished by the names of
continued or broken veins; and when the ore is found in
spherical parts or masses, from space to space, these mas-
ses are called Bellies or Stock-works.   A vein which does
not penetrate to a considerable depth in the earth, is called
by us *Coureur de Gazon.*

The characters from which mineralogists pretend to as-
sert the existence of an ore in the bowels of the earth,
are all equivocal and suspicious.   The savage aspect of
a mountain, the nature of the plants which grow upon it,
the exhalations which arise from the earth, all afford cha-
racters too doubtful for a reasonable man to risk his for-
tune upon such indications alone.   The dipping wand, or
divining rod, is the fruit of superstition and ignorance:
and the ridicule which has been successively thrown upon
this class of impostors, has diminished their number; at
the same time that the numerous dupes of this class of
men have rendered their successors more prudent.

The nature of the stones which compose a mountain
is capable of furnishing some indications.   We know, for
example, that ores are seldom found in granite, and the
other primitive mountains; we know likewise that moun-
tains of too modern a formation contain them very rarely;
and we find them only in secondary mountains, in which
the schistus and ancient calcareous stone are void of all
impressions of shells.

The presence of ponderous spar, forming a stratum or
vein at the surface of the earth, has been considered by
many mineralogists as a very good indication.   It appears
to me even that this stone is the same which Becher has
spoken of in his works, under the name of Vitrifiable
Earth, which he considered as a principle of metals; and

that it has been very improperly taken for quartz by his readers.

The vitrifiable stone of Becher—" Lapidis species quæ in igne fluit, et fluens vitrum exhibet,"—and elsewhere, " transparens enim nonnihil est, albus, et quasi, argenteis foliis interspersus, ad ignem facilè liquabilis,"—was considered by him as a certain indication of the presence of ores, as appears by the following passage : " Sine quo lapide, nulla minera bona est, nec fertilitatem promittit ; adeo enim iste lapis mineris necessarius est, ut vel nudè, et sine ullo metallo, in montibus existens, infallibile signum futuri metalli sit ; quod, hoc signo freti, non sine magnis, interdum sumptibus, quærunt minerarum indagatores ; hanc ergo sive terram sive lapidem, non sine pregnantibus causis, pro principio primo omnium metallorum, minerarum, et lapidum ac gemmarum, statuimus et agnoscimus ; certis freti experimentis, ut in sequentibus demonstrabimus, quibus evincere possumus præfatam terram actu in metallis et mineralibus omnibus, nec non lapidibus et gemmis, existere, eorumque mixtum ut basim et fundamentum ingredi ; unde ea hypostasin suam, oppositatem, diaphaneitatem, et fluxum nanciscuntur . . . . . . Hæc ergo terra non modo cum presens adest infallibile signum affuturi metalli est, sed et absens idem signum existit, defuturi nempè metalli . . . . . defectus hujus terræ proxima et frequentissima causa sterilium minerarum existit . . . . . lapis de quo egimus, non modo ut matrix sed ut ingrediens et principium."

When we possess indications of the existence of an ore in any place, we may use the borer, to confirm or destroy these suspicions, at a small expense.

It frequently happens that the veins are naked or uncovered : the mixture of stones and metals forms a kind of cement which resists the destructive action of time longer than the rest of the mountain ; and as these parts of rocks, connected by a metallic cement, present a stronger resistance to the action of waters, which incessantly corrode and diminish mountains, and carry away their parts into the sea, we frequently observe the veins projecting on the sides of the mountains incrusted with some slight metallic impression altered by the lapse of time.

Before we proceed to treat of metallic works in the large way, it will be proper to explain the methods of judging of the nature and value of an ore, in order that the members of society may not rashly hazard their fortunes. The nature of an ore is judged from inspection. A slight acquaintance with this subject is sufficient to enable the observer to form an immediate judgment of the nature of an ore. The blow-pipe is an instrument by the assistance of which we may in a short space of time become acquainted likewise with the species of the ore. This knowledge forms the docimastic art, or docimasia. In order to make the assay of an ore, in general (for all ores do not require the same process, as we shall hereafter observe,) small pieces of the mineral are examined. These are cleared from foreign and stony substances as much as possible. The pure mineral is then pounded, and a certain quantity weighed, which is torrefied in a vessel larger and less deep than a common crucible. By this means the sulphur or the arsenic in combination with the metal are dissipated; and by the loss of weight resulting from the calcination, a judgment is formed of the proportion of foreign volatile matter it contained.

This first operation shews the proportion and quantity of sulphur and arsenic which may be mixed with the metal. The sulphureous smell may easily be distinguished from the smell of garlic, which characterizes arsenic. These foreign substances mixed with the metal are called Mineralizers.

In order to obtain an accurate judgment of the weight of the mineralizer, the augmentation in weight which the metal has undergone in passing from its metallic state to that of oxide or calx, must be added to the loss occasioned by the calcination.

Two hundred grains of this roasted ore are then to be taken, and mixed with fluxes capable of fusing and reducing it. In this operation a crucible is made use of; and a sufficient degree of heat being applied, the metal is precipitated to the bottom of the crucible in a button, whose weight indicates the quantity of metal contained in the ore.

These fluxes must be varied according to the nature of the ores under examination. It is necessary that they

should all contain the coaly principle, to disengage the oxigene with which these metals are impregnated by the calcination. But the nature of the flux must be varied according to the fusibility of the metal. The three following will answer all these purposes.

1. The fusible material called black flux is made with two parts of tartar, and one part of nitre melted together. The coaly and alkaline residue is used to reduce the ores of lead, copper, antimony, &c.

2. Two hundred grains of calcined borax, one hundred grains of nitre, twenty grains of slacked lime, and one hundred grains of the ore intended to be assayed, form the flux of Scopoli, of which I have found the advantage in the assay of iron ores.

The vitreous flux of Mr. De Morveau, made with eight parts of pounded glass, one of borax, and half a part of powder of charcoal, may be employed for the same purpose.

3. Arsenic and nitre, in equal parts, form likewise a very active flux.

The neutral arsenical salt has been used with success to fuse platina.

As soon as the existence of a mine, and its nature and riches are ascertained, it is in the next place necessary to be assured of a sufficient abundance and continuity of water to answer the purposes of the works. It is likewise necessary to be assured of possessing a sufficient quantity of wood or charcoal; and, more especially, a good director must be procured: for, in my opinion, a poor mine well managed is preferable to a rich one ill conducted.

These preliminary circumstances being accomplished, the most simple and least expensive processes must be employed in extracting the mineral from the bowels of the earth. For this purpose, shafts or galleries must be dug, according to the position of the vein, and the nature of its situation.

When it is practicable to arrive at the side of the vein, and at a certain depth, by a horizontal gallery, the works become more simple and economical; the same opening serving to draw off the waters, and extract the ore. Galleries are then to be carried on to the right and left; and

shafts sunk, which communicate with the open air, as
likewise others carried down into the vein.   Galleries are
likewise constructed one above the other, and the commu-
nication of the works kept up by ladders.   When the soil
is friable, and defective in solidity, care must be taken to
support it with timbers of sufficient strength, to prevent
its falling in.

Pickaxes, wedges, and levers are used to detach the ore,
when the rock is soft; but it is most commonly necessary
to employ gunpowder, and to form mines.

Want of air, and the abundance of water, are almost
always noxious, and derange mine-works.   The water is
carried off by fire-engines, wind-mill pumps, and other
suitable apparatus.

Currents of air are produced by establishing commu-
cations with the galleries by horizontal apertures. Fur-
naces erected on the side of a shaft, to which a long tube
is adapted at one end, communicating with the ash-hole,
and at the other plunging into the shaft to draw up the
air, or ventilators placed in the same situation, answer a
similar purpose.   The foul air is destroyed by rendering
a lixivium of ashes caustic; and sprinkling quick-lime
about the mine likewise produces the same effect.

A prudent company ought to extract the largest pos-
sible quantity of ore, before they determine upon con-
structing the necessary works for the subsequent pro-
cesses.   We cannot see into the bowels of the earth.
Appearances are often deceitful; and we have seen com-
panies either ruined or discouraged, because they had em-
ployed immense sums to construct the necessary furnaces
to work an ore whose existence was doubtful.   When
the proceedings, in an undertaking of this kind, are car-
ried on with proper precaution, and no more expense is
entered into than what the ore extracted, and of a known
value, is capable of representing, the probable losses are
very slight, even in the poorest mine.

The works ought to be varied according to the nature
and state of the mineral.   It is found in three states—1.
In the form of a native metal: In this case, nothing more
is necessary than to extract it out of the mine, to clear it
of the extraneous substances, and to fuse it.   2. In the

form of calx or oxide; and in this state it is sufficient if it be sorted and fused. 3. Combined with sulphur or arsenic, in which case it must be made to undergo some other operations.

Although, in this last case, the works, subsequent to the extraction, vary according to the nature of the ore, there are nevertheless certain general operations to which every kind of ore is subjected, which we shall here speak of.

The metal is always mixed with stony substances, which are called the Gangue. The first business must therefore be to clear the metal of this foreign substance. For this purpose, when the ore is extracted, children are employed who examine it, and separate the pure ore or rich mineral from that which is mixed with the gangue. As in this second quality the stone is mixed with the ore, the whole is pulverized by means of a stamping mill, consisting of pestles of wood, shod with iron, and armed with cocks, which are raised by levers proceeding from the axis of a wheel that constantly returns. The mineral is by this means crushed and pulverized; and a stream of water which is made to pass over it, carries away both the metallic and stony particles; the former being deposited in the first vessels through which the water is made to circulate, while the latter or stony part is carried to a greater distance on account of its lightness.

This pulverized ore is called Sclich; and, in order to separate all the earthy parts, it is washed upon tables slightly inclined, over which a constant stream of water is made to flow. The sclich is agitated with brooms; the water carries away all the fragments of stone, and leaves the pure ore upon the table.

The calcination of the mineral succeeds the washing. In this operation the mineralizer is carried off. Fire is always the agent made use of. Sometimes the pounded mineral is disposed in piles upon heaps of wood, which, being set on fire, heat the ore strongly, and drive off the mineralizer. This calcination possesses the double advantage of disposing the metal for fusion, as well as clearing it of the mineralizing substance. When the ore is more friable, it is spread out in a reverberatory furnace;

and the flame which reverberates upon it deprives it of its mineralizer, at the same time that it partly fuses it.

Mr. Exchaquet has proposed to destroy the sulphur by nitre. This process is excellent for copper ores. The quantity of nitre varies according to the quantity of sulphur; but there is no danger of adding too much. In this operation the mixture is thrown into an ignited crucible, and kept at a moderate heat for some minutes.

The fusion is effected in furnaces, excited by a current of air, kept up by means of large bellows, or a machine called a *trompe*.

The trompe, or blowing machine,* is formed of a hollow tree which rests upon a cask whose lower head is knocked out, and the open part of the cask itself plunged to a certain depth under water. A current of water is made to fall through this wooden trunk upon a stone which is erected in the middle of the cask. The air becomes disengaged, and is obliged to pass out at a collateral aperture in the cask, by means of a tube which carries it to the lower part of the furnace. This air is afforded.—1. By that air which the water carries along with it. 2. By a current which passes through apertures made at the distance of six feet from the summit of the tree, and called *trompilles*.

The dimensions of a good *trompe* are the following:

Length of the tree or wooden trunk, from its summit to the side apertures or trompilles, six feet.

Length of the tree from the trompilles to the cask, eighteen feet.

Height of the cask, five feet.

Diameter of the cask, four feet six inches.

The form of the internal part of the trunk above the trompilles, is that of a funnel, whose superior opening is eighteen inches, and its inferior diameter five.

The diameter of the cavity of the tree, below the trompilles, is eighteen inches.

The diameter of the trompilles is six inches.

The stone upon which the water falls is eighteen inches in diameter.

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* I do not find, in Lewis's Commerce of Arts, where this subject is well treated, that the English have called this machine by any appropriated name.   T.

When the mineral is once cleared of its gangue, its mineralizer, and all other foreign matter, it constitutes what is called a metal or regulus.

Every fact appears to prove that metals are simple substances; the various alterations to which they are subjected, being combinations of the metal itself with other substances. None of these operations either disengage or separate any constituent part of the metal itself, as we shall see.

Every metal is fused at a certain degree of heat, more or less intense; and in this situation their surface is convex.

Messrs. Macquer and Lavoisier having exposed gold to the focus of the lens of Tschirnhausen, observed that this metal exhaled in fumes, without being decomposed; as was proved by collecting it unaltered upon presenting a plate of silver, which became gilt. Silver is volatilized in the same manner without decomposition.

Metals fused, and cooled slowly, exhibit crystallizations of considerable regularity. The abbé Mongez, and Mr. Brogniart, have succeeded in crystallizing most of them, by varying the process used by the celebrated Roulle in the crystallization of sulphur.

Most metals kept in a state of fusion lose their metallic brilliancy, and become converted into an opaque powder called Oxide, or Metallic Calx. The oxides, when urged by a stronger heat, are reduced into a vitriform substance, known by the name of Metallic Glass.

Metals acquire weight in their transition to the state of oxide. This circumstance has led several adepts into error, who imagined they had increased the weight of the metal.

Geber observes, " Ubi vel minimum augmenti metallici inveneris, ibi te dicimus esse ante fores philosophorum."—" Et sane conveniens judicium est," adds Becher; " id enim per quod corpus homogeneum augmentum capit, id ipsum est quod pro principio istius corporis haberi potest."—Phys. Subt.

Stahl pretended that the calcination of metals arose from the disengagement of phlogiston; and he considered their calces as an earth, or metallic basis.

Boyle affirmed that the increase of weight in calcined metals was owing to the combination of the matter of fire;

and Boerhaave ventured to attribute it to the surrounding bodies, which deposited themselves upon the metal.   Of all the hypotheses which have been formed upon this subject, that of Stahl has met with the greatest number of supporters : and the blind zeal of his followers has carried them so far as even to disguise an unanswerable objection ; namely, that it can never be explained how metals, by the loss of one principle, at the same time that they do not acquire another, can become heavier.   The reduction of the oxides or metallic calces, without any addition of the charcoal, cannot be explained on this hypothesis.

It must be confessed that all chemists were not of this way of thinking : and we find in the writings of Jean Rey, a Physician of Perigord, that he, in the year 1630, attributed the increase of weight in calcined metals to the combination of air with the metal.   He affirms that agitation facilitates this combination in no other manner than water renders the sand heavy which is thrown and agitated in that fluid.

He reasons like a chemist of considerable skill, to prove that the increase of weight cannot be carried beyond a point of saturation ; and he concludes his observations in these words : *Le travail a été mien ; le profit en soit au lecteur, et à Dieu seul la gloire*—" Mine has been the labour ; let the reader enjoy the advantage, and to God alone be the glory."*

All these several sketches were never formed into a connected system ; and this doctrine was even completely unknown, when Mr. Lavoisier proved to us that the calcination of metals was owing merely to the fixation of oxigenous gas, and their reduction to the disengagement of this gas, effected by simple heat, or by its combination with various bases in such instances wherein its adhesion to the metal is too strong to be overcome by mere heat.   The proofs upon which this celebrated chemist has established his opinion, are the following facts.

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* This is the same Jean Rey, who, being under the necessity of contradicting his friend Libavius on the theory of the calcination of metals, exclaims—" O Truth, how dear art thou to me! since it is in thy power to make me enter into a contest with so dear a friend."

1. Metals are not oxided either in a vacuum, or in air which contains no part of oxigenous gas. The Count Morozzo, Priestley, Lametherie, and Pictet appear to have oxided lead, tin, and mercury in the carbonic acid. See the Memoir of Mr. Sennebier, Journal de Physique, Fevrier 1787.—But this pretended oxide is nothing but a metallic carbonate, or the combination of a metal with an acid, which is very far from calcination or oxidation.

2. Metals inclosed under a glass, and properly heated, are oxided only by absorbing the oxigenous gas contained in the mass of air which is insulated; and when this absorption is ended, it is impossible to carry the oxidation any further.

3. Metals oxided in an atmosphere of oxigenous gas absorb it to the last drop.

4. Such oxided metals as are capable of being reduced in closed vessels, give out, on their return to the metallic state, the same quantity of oxigenous gas as they had before absorbed.

This doctrine appears to me to be established on the most complete series of proofs which can be desired in matters capable of demonstration.

The concurrence of air and of humidity singularly assists the alteration of metals. The water is decomposed in this process, and its hydrogene is dissipated, while its oxigene combines with the metal. This is doubtless the theory of such oxidations as are effected beneath the surface of water; and when we find oxides, or metallic calces, in the bowels of the earth, defended from the contact of air, the facts ought to be referred only to the decomposition of water, or of acids which have oxigene for their base.

Hence it follows that the alteration of a metal will be the more speedy—1. In proportion as the affinity of the metal to oxigenous gas is stronger. 2. As the quantity of oxigenous gas is greater. 3. As the air is more humid, &c. Metals decompose certain substances in order to unite with their oxigene, and by that means to pass to the state of oxide. This is observable when the nitric acid is digested upon certain metals.

Metallic substances being considerably numerous, it is necessary to class them, that we may bring together such as possess similar properties, and separate others which differ from them.

Ductility serves as a leading character. Metals may be distinguished into such as are ductile, and such as do not possess this property. The name of Metal has been peculiarly applied to the former, and that of Semi-metal to the latter kind.

Among the metals there are some which are changeable by exposure to air, while others are not sensibly altered in the same situation. This difference has caused a subdivision of the metals into perfect and imperfect metals.

We shall begin by treating of the semi-metals, because for the most part they approach to the saline or stony substances in their qualities; and we shall conclude with the perfect metals, because they possess the metallic qualities in an higher degree.

CHAPTER I.

Concerning Arsenic.

THE substance which is sold in commerce under the name of arsenic, is a metallic oxide of a glittering whiteness, sometimes of a vitreous appearance; exciting an impression of an acrid taste on the tongue; volatile when exposed to fire, in which situation it rises in the form of a white fume, with a very evident smell of garlic.

Although arsenic is most commonly met with under this form, it may be reduced to the metallic state by treating it with oils, soaps, or charcoal in closed vessels. The celebrated Becher was perfectly acquainted with this process.—" Si oleum, vel quodcunque pingue, arsenico misceas, et per retortam distilles urgenti igne, sublimabitur in collum arsenicum, insignitur antimonii instar metallizatum."—The arsenic which sublimes is of a brilliant grey colour, resembling steel, but it speedily becomes black in the air: it forms crystals, which Mr. De Lisle considers as aluminiform octahedrons.

Arsenic is sometimes found native; and it is met with in stalactites, or in protuberant depositions formed of layers more or less distinct and concentric, which are separable

from each other like the coats of an onion, or the laminæ of shells, from which it has obtained the name of testaceous arsenic. In other instances the masses are formed of very small scales; which renders the surface of the specimen sometimes granulated, and sometimes full of small cavities: it is then called scaly arsenic. Arsenic is also found in friable masses, possessing scarcely any consistence. In these various forms we receive it from Bohemia, Hungary, Saxony, Saint Marie aux Mines, &c.

Arsenic is volatilized by an heat of about 144 degrees of Reaumur. In order to set fire to this metal, it must be thrown into a crucible strongly ignited: and then it exhibits a blue flame, and rises in the form of a white oxide.

If it be sublimed by a gentle heat, it crystallizes in trihedral pyramids, or in octahedrons.

Arsenic is not soluble in water. Its specific gravity is 57633, according to Brisson. Its fracture resembles that of steel, but it easily tarnishes.

Arsenic appears to exist in the metallic state in its combinations with cobalt in the testaceous cobalt ore, or with iron in mispickel, according to the observation of Bergmann.

Arsenic unites by fusion with most of the metals; but those which were ductile before this addition, become brittle afterwards. Those which are of difficult fusion alone flow more easily by heat with the addition of arsenic, and those which are very fusible become refractory by the same addition. The yellow or red metals become white with this alloy.

Arsenic is often combined with metals in various ores, and is disengaged from them by calcination. In various mine works, long winding chimneys are constructed, through which the arsenical vapours pass, and in which they attach themselves. The crust which is formed in process of time against the internal surface of these chimneys is taken away, and is the substance met with in commerce under the name of arsenic. The cobalt ores of Saxony, which are torrefied to separate this semi-metal, afford almost the whole of what is sold. This oxide of arsenic is sometimes native, and has been found in Saxony and Bohemia. It is very abundant in such places as are situated in the vicinity of subterranean fires, such as the

Solfatara. It is often found crystallized in octahedrons, according to Mr. Sage.

The oxide is less volatile than the metal itself; and, as we have before observed, it emits a very evident smell of garlic. If it be sublimed by a strong fire in closed vessels, it becomes transparent like glass; but its surface is soon rendered opaque again by exposure to air. It is not rare to find arsenical glass in the arsenic of commerce: it is yellowish, and soon loses its transparency by exposure to air. This glass is sometimes found native in the cobalt mines, and among volcanic products.

Eighty parts of distilled water, at the temperature of twelve degrees, are required to dissolve one part of the oxide of arsenic; but fifteen are sufficient at the boiling heat.

One part of arsenic is soluble in between seventy and eighty parts of alcohol at the boiling heat.*

The oxide of arsenic partakes therefore of the properties of saline substances, and differs from the other metallic oxides—1. Because it is perfectly soluble in water. 2. Because the other metallic oxides are without smell, and fixed in the fire. 3. Because those oxides do not contract any union with metals.

On the other hand it resembles the metallic oxides—1. In becoming converted into a metallic glass by a strong heat. 2. In forming an opaque insoluble substance, possessing the metallic brilliancy when deprived of oxigene.

The oxide of arsenic is capable of combining with sulphur; and the result is either orpiment or realgar, according to the manner of operating.

Most chemists have a notion that the realgar contains more sulphur than the orpiment; and they have prescribed different proportions to form these two substances. But it has been proved by Mr. Bucquet, that this difference of colour arises only from the manner of applying the fire; nothing more being necessary to convert orpiment into realgar, than the exposing it to a strong heat: and with the same mixture we may at pleasure obtain either of these products, according to the manner of applying the heat.

* If arsenic in its pure metallic state, be kept covered with alkohol, it will preserve its metallic brilliancy.—*Am. Ed.*

Orpiment and realgar are found native in certain places. Linnæus, Wallerius, Bergmann, and Cronstedt have described them.*

Crystals of realgar are found in Solfatara near Naples, according to Ferber; in the mines of Nagyag in Transylvania (see Forster's Catalogue;) in the mines of Felsobanya in Upper Hungary; in those of Joachimstal in Bohemia, and of Marienburg in Saxony.

Realgar is common in China; it is made into vases, pagods, and other ornamental works. The Indians make use of these vessels to procure a purgative medicine: for this purpose they leave vinegar or lemon juice for several hours in the vessel, and afterwards drink it.

Realgar is commonly found in the waters of volcanos, I have almost always observed it in compressed hexahedral prisms, terminating in two tetrahedral summits.

Orpiment is less scarce than the realgar. It almost always accompanies this substance; but the orpiment of commerce comes to us from various countries up the Levant, in irregular masses, solid or lamellated, and of a beautiful orange yellow. The Baron de Born informs us that it is met with, in polyhedral crystals, in a blueish clay near Newsol in Hungary.

Lime and the alkalis decompose these two substances, and disengage the oxide of arsenic.

The acids and the alkalis exhibit interesting phenomena with arsenic.

The sulphuric acid, when boiled on the oxide of arsenic, attacks and dissolves it; but this oxide is precipitated by cooling. If the whole of the acid be dissipated by a strong heat, the arsenical acid remains behind.

The nitric acid, assisted by heat, dissolve the oxides of arsenic, and forms a deliquescent salt, of which we shall presently treat.

The muriatic acid attacks arsenic very feebly. Messrs. Bayen and Charlard found its action very weak whether heated or cooled.

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* A specimen of the sulphuret of arsenic, weighing about four ounces, was found about two miles from Philadelphia, in digging a cellar.— *Am. Ed.*

In order to form the sublimed muriate of arsenic, or butter of arsenic, equal parts of orpiment and corrosive sublimate of mercury are mixed together. The mixture is distilled by a gentle heat; and the receiver is found to contain a blackish corrosive liquor, which forms the sublimed muriate of arsenic. Cinnabar comes over if the heat be increased, according to the observation of Mr. Sage.

If pure potash be boiled on the oxide of arsenic, the alkali becomes brown, gradually thickens, and at last forms a hard brittle mass. This arsenical salt of Mr. Macquer is deliquescent. It is soluble in water, which lets fall brown flocks. It is decomposed by fire, and the arsenic escapes. Acids deprive it of its alkali, &c.*

Soda exhibits phenomena nearly similar with this oxide; and Mr. Macquer even affirms that he obtained this salt in crystals.

I have proved that ammoniac dissolves the oxide of arsenic by heat; and I have several times obtained crystals of arsenic by spontaneous evaporation. I am even of opinion that the alkali is decomposed in these circumstances, that the nitrogene is dissipated, while the hydrogene unites with the oxigene of the oxide, and forms water.

The oxide of arsenic hastens the vitrification of all the earths; but the glasses into which it enters as a component part, have the property of easily becoming tarnished.

Equal parts of nitre and oxide of arsenic, distilled in a retort, afford a very red and almost incoercible nitric acid. Stahl and Kunckel obtained it by a process nearly

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* Fowler's solution of arsenic is prepared in the following manner: Take white arsenic in fine powder and potash, of each 64 grains. Boil them in half a pint of water until the arsenic is entirely dissolved. Then add, when the mixture has grown cold, another half a pint of water, and half an ounce measure of lavender compound. The dose of this medicine for an adult is ten drops, two or three times every day. It is used in intermitting fevers, in rheumatism, in periodical headaches, and in cutaneous eruptions.

Dr. Darwin prefers a saturated solution of arsenic, which may be made in an oil flask or tin saucepan. He supposes it acts by stimulating the stomach into strong action, and thus by the association of this viscus, with the heart and arteries, prevents the torpor of any part of the sanguiferous system.—*Am. Ed.*

similar. Macquer having resumed this work, carefully examined the residue in the retort, and found that it was a salt soluble in water, capable of crystallizing in tetrahedral prisms terminated by four-sided pyramids, unalterable in the air, fusible by a moderate heat, but without becoming alkalized. Mr. Macquer called it the neutral arsenical salt : he supposed that no acid could decompose it. But Mr. Pelletier proved that the sulphuric, when distilled with it, disengaged its acid.

The arseniate of soda differs little from the arseniate of potash. Mr. Pelletier obtained this salt crystallized in hexahedral prisms, terminated by planes perpendicular to their axes.

By these several experiments, Mr. Macquer had shewn that arsenic answered the purpose of an acid in these combinations. There remained only one step therefore to be made, to prove that it was really metamorphosed into an acid in these several operations : and it is to the celebrated Scheele that we are indebted for this discovery. His capital experiments upon manganese naturally led him to it.

He has given us two processes to obtain this arsenical acid ; the first by means of the oxigenated muriatic acid, and the other by the nitric acid. These acids are distilled from the oxide of arsenic : the muriatic acid abandons its oxigene to the oxide of arsenic, and resumes the characters of the ordinary muriatic acid. The nitric acid is itself decomposed ; and one of its principles is dissipated, while the other is fixed and combines with the arsenical oxide.

This acid is at present obtained by distilling six parts of nitric acid from one of oxide of arsenic.

Mr. Pelletier likewise proposes to decompose the nitrate of ammoniac by the oxide of arsenic. The residue in the retort is the arseniate of ammoniac, from which the alkali may be driven by a fire long kept up. The residue is a vitreous mass, strongly attracting humidity, and falling into deliquium. It is the pure arsenical acid.

Mr. Pelletier has likewise decomposed the neutral arsenical salt, by mixing it with half a part of oil of vitriol, and urging the fire to such a degree as to ignite the vessels. The residue at the bottom of the retort is a white mass, which attracts humidity, and is the arsenical acid.

A white powder is observable, which is found to be the
sulphate of potash or of soda, accordingly as the arseni-
cal salt has soda or potash for its basis.

From the various processes made use of to form the
arsenical acid, it is evident that this substance is nothing
but the arsenical oxide, saturated with the oxigene which
it takes from the various bodies digested upon it.   The
nitric acid, or the nitrates used for this purpose, are de-
composed ; the nitrous gas passes over very abundantly,
and the oxigene remains mixed and united with the oxide
of arsenic.

This acid possesses the concrete form ; but it attracts
the humidity of the air, and becomes resolved into a fluid.

It is fixed in the fire ; but if it be heated in contact
with a coaly substance, it is decomposed, and the oxide
exhales in the form of fumes.   It is reduced into arsenic,
according to Mr. Pelletier, by passing hydrogenous gas
through it.

At the temperature of twelve degrees of the thermo-
meter of Reaumur, this acid requires only two-thirds of
its weight of water to dissolve it ; whereas one part of the
oxide of arsenic requires twenty-four of water to dissolve
it at the same temperature.

This acid, when dissolved in water may be again con-
centrated, and carried to the state of a transparent glass
without any alteration ; for it is not by this treatment de-
prived of its power of attracting humidity from the air.

When it is in this state of concentration, it acts strongly
on the crucible, and dissolves the alumine, according to
Mr. Berthollet's experiments.

The arsenical acid, saturated with ammoniac, and duly
evaporated, forms a salt crystallized in rhomboides ;
which, when urged by heat, loses its water of crystalli-
zation, next its alkali, and is resolved into a vitreous
mass.

Barytes and magnesia appear likewise to have a stronger
affinity with this acid than the alkalis, according to Berg-
mann.   Lime decomposes the neutral salts with base of
alkali, according to the experiments of the same chemist.

Arsenic is used by the dyers : it is likewise used as a
flux in glass-houses, and in docimastic works ; it also en-
ters as a component part into some glazes.   Orpiment and

realgar are very much used by painters; but arsenic is one of those productions whose advantages are not sufficient to compensate for its bad effects. This metal, which is very abundant, and very frequently met with in mines, causes the destruction of a number of workmen who explore them : being very volatile, it forms a dust which affects and destroys the lungs; and the unhappy miners, after a languishing life of a few years, all perish, sooner or later. The property which it possesses of being soluble in water, multiplies and facilitates its destructive power; and it ought to be proscribed in commerce, by the strict law which prohibits the sale of poison to unknown persons. Arsenic is every day the instrument by which victims are sacrificed, either by the hand of wickedness or imprudence. It is often mistaken for sugar; and these mistakes are attended with the most dreadful consequences. Whenever there is the least reason to suspect its presence, the doubt may be cleared up by throwing a small quantity of the powder upon heated coals. The smell of garlic, and the white fumes, are indications of the presence of arsenic. The symptoms which characterize this poison are, a great constriction of the throat, the teeth set on edge, and the mouth strongly heated ; an involuntary spitting, with extreme pains in the stomach; vomiting of glairous and bloody matter, with cold sweats and convulsions.

Mucilaginous drinks have been long ago given to persons poisoned by arsenic. Milk, fat oils, butter, &c. have been successively employed.—Mr. Navier has proposed a more direct counterpoison. He prescribes one dram (gross) of sulphure of potash, or liver of sulphur, to be dissolved in a pint of water, which the patient is directed to drink at several draughts : the sulphur unites to the arsenic and destroys its causticity and effect. When these first symptoms are dissipated, he advises the use of mineral sulphureous waters. He likewise approves of milk, but condemns the use of oils. Vinegar, which dissolves arsenic, has been likewise recommended by Mr. Sage.

CHAPTER II.

Concerning Cobalt. *

COBALT was employed by artists to give a blue co-
lour to glass, long before it was supposed to con-
tain a semi-metal. We are indebted to Brandt, a cele-
brated Swedish mineralogist, for the knowledge of its
properties, and metallic character.

The specific gravity of fused cobalt is 78.119. See
Brisson.

Cobalt is combined in the bowels of the earth with sul-
phur, arsenic, and other metallic substances.

1. The arsenical cobalt ore is of a grey colour more or
less deep, dull in its fracture, and becoming black on ex-
posure to the air ; in consequence of an alteration in its
arsenical part.

This ore of cobalt crystallizes in smooth cubes, and
affects several varieties. I have a piece which has the
form of tetrahedral pyramids, joined base to base. This
species of cobalt sometimes affects a confused crystalliza-
tion in dendrites, and is then called Knit-cobalt ore.
Sometimes it is found in protuberances, stalactites, &c.

The sulphureous ore of Cobalt resembles the grey sil-
ver ore in its texture : it contains iron and silver ; and ef-
floresces of a lilac colour, mixed with a yellowish green.
—Sage, Annal. Chem. t. ii.

Mr. De Lisle possesses specimens of this kind, which
came from the mine of Batnaes at Riddarhyttan.

* The word *cobalt* is derived from *cobalus*, which was the name of
a spirit, that according to the notions of miners haunted mines, de-
stroyed the labours of the miners, and often gave them a great de-
gree of unnecessary trouble. The miners perhaps gave this name
to the mineral out of joke, because it thwarted them as much as the
supposed spirit, by exciting false hopes, and rendering their labour
often fruitless, for it was known at first, to what the mineral could
be applied. as it was thrown aside as useless. It was once custom-
ary in Germany, to introduce into the church service, a prayer that
God would preserve miners and their works from *kobalts* and spirits.
(Beckman's History of Inventions.)—*Am. Ed.*

3. Cobalt is mineralized by sulphur and arsenic, in the mine of Tunaberg in Sudermania.*

The crystallization of this species is a cube striated on its six faces, and commonly truncated more or less deeply on its edges.

This ore contains, according to Mr. Sage, fifty-five pounds of arsenic, eight of sulphur, two of iron, and thirty-five of cobalt.

4. The ores of cobalt are sometimes in efflorescence ; and the sulphureous ore forms by its decomposition the sulphate of cobalt.

The sulphure of cobalt, and the arsenical cobalt ore, pass to the state of oxide in their decomposition ; and the surface becomes covered with a colour of peach flowers, more or less intense. It is sometimes coloured with an efflorescence in the figure of stars formed by radii applied to each other collaterally, and all tending to a common centre. This is an indistinct crystallization, in which Mr. De Lisle thinks he observed tetrahedral prisms terminated by dihedral summits. The flowers of cobalt are frequently a mere powder, more or less coloured. Those ores which are in a state of complete decomposition are called Soft or Earthy cobalt ores.

To assay an ore of cobalt, the first process is torrefaction. Two hundred grains are afterwards fused with an ounce and a half of black flux. Mr. Sage is confident that more metal is obtained by mixing the oxide of cobalt with two parts of white glass, and a small quantity of coal.

When cobalt is mixed with bismuth and iron, its oxide must be distilled with equal parts of the muriate of ammoniac, until the salt which sublimes in the neck of the retort has acquired a green tinge. Mr. Sage, who gives us this process, observes that seven or eight sublimations are sometimes necessary to deprive the cobalt of all the iron and bismuth which it contains.

* Mr. Benjamin Henfrey informs us, that cobalt of a good quality has been found in this country, but he does not say in what part.*—*Am. Ed.*

* Plan for working mines, p. 30.

Cobalt is of a light grey colour, compact and brittle. It is not easily fused, is not volatile, resists cupellation, and refuses to amalgamate with mercury.

The working of cobalt ores is very simple.   It consists in roasting the ore in a reverberatory furnace terminating in a long chimney, into which the vapours are received. These vapours, or arsenical fumes, attach themselves to the sides, and form a crust, which is cleared off by cri- minals, who are condemned to this work for crimes that by the law deserve death.   The cobalt ores of Saxony af- ford all the arsenic of commerce.   When the oxide of cobalt is cleared of arsenic, it is known by the name of Zaffer.   The zaffer of commerce is mixed with three- fourths of sand.   This oxide, fused with three parts of sand, and one of potash, forms a blue glass, which, when pounded, sifted, and afterwards ground in mills, included in large casks, forms Smalt.   In order to obtain the blue of various degrees of fineness, the smalt is agitated in casks filled with water, and pierced with three openings at different heights.   The water of the upper cock carries out the lightest blue, which is called Azure of the First Fire : the heavier particles fall more speedily ; and the azure brought out by the water of the three cocks, forms the different degrees of fineness known under the names of Azure of the First, Second, and Third Fire.

Bohemia and Saxony have hitherto possessed the exclu- sive power of supplying us with these products.   A des- cription of these capital works may be seen in the minera- logical productions of Messrs. Jars.   The works of Saxo- ny have been supplied, for several years, by the cobalt ore discovered in the Pyrenean Mountains in the valley of Gisten.   But the Comte de Beust has formed establish- ments which secure to us the benefit of this commerce ; and he has even been so fortunate as to find, near the vil- lage of Juget, a quartz sufficiently charged with cobalt to admit of being fused without any addition of colouring matter.

The establishment of the Comte de Beust is capable of manufacturing six thousand quintals of azure, or enamel blue; and is able not only to supply our wants, but to en-

ter into competition with the works of Saxony for the fo-
reign trade.*

He has likewise, in concert with the Baron Dietrich,
discovered the process of making powder blue; a secret
which was exclusively in the possession of the Hollanders
till the present time.

Smalts are used in the preparation of cloths, laces, li-
nens, muslins, thread, &c.

The azures are mixed with starch, and form the blue
so well known and universally used by laundresses.

It is likewise employed in forming blue paintings on
fayence, porcelain, and other potteries; crystals and glasses
are coloured blue by this substance; and it is also used
in painting in fresco.

The coarsest blues are used by the confectioners and
others, in the way of ornament ; and in Germany they are
used as sand for writing-paper.

The consumption of smalt, azure, blue sands, and zaf-
fers, in the kingdom of France only, is estimated at four
thousand quintals, which are sold from seventy-two to six
hundred livres the quintal.

Cobalt is soluble in the acids.

One part of this metal, distilled with four parts of sul-
phuric acid, affords the sulphureous acid; and the residue
in the retort is the sulphate of cobalt, soluble in water,
and capable of crystallizing in tetrahedral rhomboidal crys-
tals, terminating in a dihedral summit.

Barytes, magnesia, lime, and alkalis decompose this salt,
and precipitate the cobalt in the form of oxide.

One hundred grains of cobalt dissolved in the sulphuric
acid, and precipitated by soda, afford one hundred and
forty grains of precipitate, and one hundred and sixty
when precipitated by chalk.

The nitric acid dissolves cobalt with effervescence. The
solution affords crystals in needles, which have not been
strictly examined. This salt is deliquescent, boils on the
coals without detonating, and leaves a deep red calx.   I

* A description of the works of the Comte de Beust may be seen
in the *Description des Gîtes des Minérais, des Forges, et des Salins des
Pyrénées, par M. le Baron de Dietrich.*

have seen this salt in very short beautiful hexahedral py-
ramids. It decrepitates and fuses on charcoal.

The muriatic acid does not dissolve cobalt in the cold,
but by the assistance of heat it dissolves a portion of it.
This acid acts more effectually upon the zaffer, and the
solution is of a very fine green, and when diluted with wa-
ter constitutes a very singular sympathetic ink: for it
passes from a lilac, or violet colour, to purple, green, and
black.*

The nitro-muriatic acid likewise dissolves cobalt, and
forms the sympathetic ink, which Hellot has called the
Ink of Bismuth.†

Ammoniac likewise dissolves zaffer, and produces a li-
quor of a beautiful red colour.‡

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* Green sympathetic ink of cobalt, is prepared in the following
manner :

Put into an oil flask one part of cobalt and four of the nitric acid.
Apply a gentle heat until the solution be nearly completed ; then add
common salt equal to the cobalt employed, and four times as much
water as nitric acid.

If letters be written on white paper with this solution, they will
be invisible ; but by exposing the paper to a gentle heat, they will ap-
pear of a beautiful green colour.—*Am. Ed.*

† The acetic acid will not act upon cobalt in its metallic state, but
its oxide is dissolved by it with the assistance of heat.

The acetate of cobalt forms a blue sympathetic ink, which may be
prepared in the following manner :

Put one ounce of cobalt in fine powder into an oil flask, and add to
it two ounces of nitric acid. Expose the mixture to a gentle heat,
and when the cobalt is dissolved, add a solution of potash to it, until
no precipitate takes place. Wash this precipitate in water, and dis-
solve it in distilled vinegar, with the assistance of heat, so as to have
a saturated solution. Add some sea salt, and the ink will be made.—
Am. Ed.

‡ The oxide of cobalt has been administered in rheumatism, in sy-
philis, in eruptions of the skin, and in pulmonary consumption. The
dose for an adult is from six to twenty grains. It excites sickness of
the stomach, and proves laxative.—*Am. Ed.*

CHAPTER III.

Concerning Nickel.

HYERNE appears to have been the first who treated of nickel, under the name of Kupfernickel, in 1794, in a work on minerals.

Henckel considered it as a species of cobalt, or arsenic mixed with copper.

Cramer has likewise placed it among the ores of copper; and it was not until the year 1751, that Cronstedt obtained a new semi-metal from this pretended mixture.

Kupfernickel is found not only in the German districts, but likewise in Dauphiny, and in the Pyrenean Mountains. In digging out a calcareous stone for building, at Bareges, and opposite St. Sauveur, small veins and lumps of nickel were found in the calcareous spar, some parts of which were reduced to the state of green oxide. Mr. Sage, who analyzed that of Biber in Hesse, and that of Allemont, found it to contain gold.

In order to obtain nickel from its ore, it must first be torrefied to disengage the arsenic ; and the oxide must then be fused with three parts of black flux, and a small quantity of coal. This metal is of a reddish grey colour.

The specific gravity of fused nickel is 7,8070. Brisson.

As it is very difficult to drive off all the arsenic by a previous torrefaction, the metal, when urged by a violent fire, still suffers arsenic to escape.

The methods pointed out by Bergmann and Arvidson to purify nickel, consist in repeated calcinations and reductions; but these operations separate the arsenic only ; and Bergmann admits that he did not succeed in completely depriving it of its iron, though he treated it by every suitable method. He seems disposed to consider it as a modification of iron.

The Dissertation of Bergmann De Nicolo, Opuscula, t. ii. may be consulted on the nature of this metal ; and also the Analyse Chimique of Mr. Sage, &c.

The sulphuric acid distilled upon nickel affords sulphu-
reous acid, and leaves a greyish residue, which, when dis-
solved in water, communicates to it a green colour.

The sulphate of nickel effloresces in the air.

Nickel is attacked very strongly by the nitric acid.

The solution, when evaporated, affords crystals of a
beautiful green, in rhomboidal cubes.

The nitric acid likewise dissolves the oxide of nickel,
and forms with it deliquescent crystals of a fine emerald
green, and of a rhomboidal form, according to Bergmann.

The muriatic acid dissolves nickel, when heated.   The
solution produces crystals of the most beautiful emerald
green, and of the figure of long rhomboidal octahedrons.

Cronstedt has taught us that nickel combines with sul-
phur by fusion, and that the result is a hard yellow mine-
ral, with small brilliant facets.   The same chemist dis-
solved this last metal in the sulphure of potash, and formed
a compound resembling the yellow copper ores.

Nickel does not amalgamate with mercury.*

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CHAPTER IV.

Concerning Bismuth.

BISMUTH, or tin-glass, is a semi-metal of a shining
yellowish white, disposed in plates and chatoyant.
It has some analogy with lead; and, like that metal, it
passes off on the cupel, carrying the baser metals along
with it.

* Some chemists have asserted that nickel is magnetic ; but Mr.
Chenevix has shewn, that the magnetism of common nickel is owing
to iron which adheres to it.   A portion of this metal, so small as not
to be detected by the best chemical tests, when it is combined with
nickel, is susceptible of communicating magnetic properties to the
whole mass, as strong as if the whole were composed of steel.—
Am. Ed.

The specific gravity of fused bismuth is 9,8227.—See Brisson.

Bismuth is the most easily fused of all the semi-metals, after tin.   It requires only the 200th degree of heat.

It is found in various states in the bowels of the earth, either native, or combined with sulphur, arsenic, or oxigene.

1. Native bismuth is sometimes crystallized in cubes :' Wallerius and Cronstedt found it in this form in the mines of Schneeburg in Saxony.   These crystals often re-unite in the form of dendrites, in the spathose or quartzose gangues.   Native bismuth is found in masses, covered with protuberances resembling stalactites.

Native bismuth is frequently altered by a slight decomposition of its metallic surface.

The native bismuth of Saxony is sometimes irised, and mixed with arsenic: it has a reddish jasper for its gangue.

2. Arsenical bismuth is of a whitish and brilliant grey colour.   This ore is sometimes covered with an ochre of bismuth, and often contains cobalt.   I have seen pieces of arsenical bismuth, from Schnecburg, in the form of dendrites on a gangue of jasper.

3. We are indebted to Mr. Cronstedt for the knowledge of a sulphureous ore of bismuth.   That which he has described is of a blueish brilliant grey colour.

This species frequently possesses the lamellated texture of the large plated galena, which has caused Linnæus, Wallerius, and others, to give it the name of Galena of Bismuth.   It is found at Batneas, at Riddarrhitan in Westmanland.   It decrepitates on heated coals, and requires to be pulverized, in order to torrefy it without loss.

The galena of bismuth is sometimes striated.

The sulphureous ore of bismuth is sometimes compact, of an obscure colour, sprinkled with small brilliant points. That of Schneeburg in Saxony is of this kind.

Mr. De La Peyrouse discovered, in 1773, on the mountains of Melles in Cominges, in the quarter called Les Raitz, an ore of bismuth, which resembles this small plated galena, and has no external difference, excepting that it is less heavy.   This ore is mineralized by sulphur, in the proportion of thirty-five livres per quintal.

4. Cronstedt, Linnæus, Justi, and De Born, have spoken of a bismuth ore of a greenish yellow, found in Saxony, and in Sweden. Mr. Sage communicated to the Academy, on the 17th of August, 1780, the analysis of an earthy, solid, yellowish green ore of bismuth. He obtained quartz in the proportion of one-third, some carbonic acid, thirty-six pounds of bismuth per quintal, and twenty-four grains of silver: he found neither copper nor iron. Besides this green ore, he analyzed a yellow, solid, slightly brilliant, and sometimes semi-transparent ore, which afforded him nearly the same results, but nine pounds more of bismuth.

This oxide must be fused in the blast furnace.

The fusibility of bismuth renders the working of this ore very simple, and the apparatus may be varied in several ways. Nothing more is necessary than to throw the ore into the fire, and to make a cavity underneath to receive the semi-metal.

Bismuth, when heated to redness, burns with a blue flame, scarcely perceptible. Its oxide rises in the form of a yellowish fume, which, when condensed, forms the flowers of bismuth. Its weight is increased twelve per cent. in passing to the state of oxide.

Mr. Darcet has converted bismuth into a glass of a dull violet colour.

Bismuth may be substituted instead of lead, in the process of cupellation. Its vitrification is even more speedy.

The sulphuric acid, boiled on bismuth, suffers sulphureous acid to escape, and partly dissolves the semi-metal. The sulphate of bismuth does not crystallize, but is very deliquescent.

The nitric acid attacks bismuth, and is very speedily decomposed. Nitrous gas is disengaged, while the oxigene is fixed in combination with the metal. There is nevertheless a portion dissolved which is capable of forming a salt in rhomboidal, tetrahedral prisms, terminating in a tetrahedral pyramid with unequal faces. This nitre detonates weakly with reddish scintillations; and melts, swells up, and leaves an oxide of a greenish yellow colour.

This salt loses its transparency in the air, at the same time that its water of crystallization flies off.

The muriatic acid does not act on bismuth but in the course of a considerable time ; and for this purpose it must be highly concentrated. The muriate of bismuth is of difficult crystallization, and strongly attracts the humidity of the air.*

Water precipitates this semi-metal from all its solutions ; and the precipitate, when well washed, is known by the name of magistery of Bismuth, or white paint for the complexion. This white is used as a pigment for the skin ; but strong or sulphureous vapours, and even the animal transpiration, convert it into metal, and alter its colours. The hair-dressers, when they are desirous of converting hair to a black colour, smear it with pomatum prepared with the magistery of bismuth.

Bismuth is used by the pewterers to give hardness to the metallic composition of pewter.

Mr. Pott has published a dissertation, in which he affirms that physicians have made use of some preparations of this semi-metal ; but it is proper that it should be prohibited, because it almost always retains a portion of arsenic, and itself partakes of the noxious properties of lead.

The white of bismuth is very much used as a paint for the complexion. Its various solutions form sympathetic inks, which are more or less curious, on account of the facility with which this oxide is altered, and becomes black.

Schluter, in his Treatise of the Fusion of Ores, pretends that it may be used in making the azure blue glass. But it appears, from his own account, that he made use of a bismuth ore very rich in cobalt. For he says, that a moderate fire causes this ore to suffer its bismuth to flow out, and that residue is a grey and fixed earth, which may be employed to advantage in making the blue.

This semi-metal unites with all the metals ; but very difficultly, in the way of fusion, with the other semi-metals, or the metallic oxides. Antimony, zinc, cobalt, and arsenic refuse this union.

Bismuth, fused with gold, renders it eager, and communicates to it its own colour. It does not render silver

* Bismuth inflames in oxigenated muriatic acid gas.—*Am. Ed.*

so brittle as gold : it diminishes the red colour of copper, but is deprived of its own colour by uniting with lead ; the two metals, in this case, forming an alloy of a dark grey colour. When bismuth is mixed in a small propor- tion with tin, it gives it a greater degree of brilliancy and hardness. It may be united with iron by a violent heat.

Bismuth amalgamates with mercury, and forms a fluid alloy ; a circumstance which has induced certain unprin- cipled druggists to mix it with that metal. The fraud may be known from the mercury being less fluid than be- fore, and no other test is necessary than to dissolve the mixture in spirit of nitre ; for the bismuth will be preci- pitated by the addition of water.

This property, however, of amalgamating completely with mercury, may cause it to be applied with advantage in the silvering of glasses, by an amalgam of tin, bis- muth, and mercury. This is, perhaps, the circumstance which has obtained it the name of tin-glass.

The fusible alloy of Mr. Darcet is a mixture of eight parts of bismuth, five of lead, and three of tin. It melts in water at the seventy-third degree of Reaumur, and flows like mercury.*

CHAPTER V.

Concerning Antimony.

ANTIMONY is a semi-metal which has singularly engaged the attention of alchemists. They consi- dered it as the basis of their great work ; and it is de-

* Baumé has given the magistery of Bismuth in three cases of chronic diseases of the stomach with success. The dose at first was one grain three times a day, and it was increased one grain every other day to six grains for a dose.

According to Schroeder, the acetate and tartrate of Bismuth are purgative. Of the latter he says—" Serum purgat potentissime, hydropecos ad miraculum juvat." The calx of this metal is in- serted in the Strasburg Pharmacopœia, and it is said to be an ex- cellent remedy in the intermittent fever.—*Am. Ed.*

scribed in their writings under the names of the Radical Principle of Metals, Sacred Lead, &c.

This semi-metal is famous for the disputes which were maintained concerning it, at the beginning of the sixteenth century. It was prohibited by a decree of parliament, at the solicitation of the faculty of Paris. Pourrier of Caen, a skilful physician and chemist, was degraded by the Faculty of Medicine, for having employed it in 1609.

This same proscribed metal was re-established in 1624; and at present affords the most powerful remedies possessed by the medical art.

Bazilius Valentinus, a zealous partisan of antimony, pleaded its cause with much warmth and enthusiasm, in a work entitled Currus Triumphalis Antimonii: and Lemery has written a large volume to decry the preparations of this semi-metal.

As this substance afforded employment for a long time to the alchymists, its study is rendered particularly difficult by the multiplicity of preparations, and the barbarous names which have been given to them, and to the variety of processes. But by confounding preparations of the same nature; by bringing the analogous products together, rejecting at the same time the numerous list of barbarous names which have been bestowed on one and the same thing; and by reducing the processes to that simplicity of which the well-known preparations are susceptible; we may succeed in forming an accurate and precise idea of the nature and properties of this metal.

Antimony is found in the bowels of the earth, in four different states.

1. In the metallic form.
2. Combined with arsenic.
3. Mineralized with sulphur.
4. In the state of oxide.

1. Some authors pretend that antimony in the metallic state was discovered in the year 1748, by Ant. Swab, in the mine of Sahlburg, in Sweden. Swab affirms that it has the colour of silver, that its texture is formed of large brilliant plates, and that it easily amalgamates with mercury. Cronstedt, Wallerius, Linnæus, and Cartheuser, do not hesitate to admit of native antimony; but Lehman, Justi, and Vogel deny its existence: and Mr. De

Lisle thinks that this pretended regulus is nothing but the
white arsenical ore of antimony. The abbé Mongez af-
firms that he has discovered native antimony at Allemont
in Dauphiny. It is the same ore which Mr. Sage has de-
scribed under the name of the Arsenical Ore of Anti-
mony.

If this native Antimony really exists, it is probably
crystallized like the metal itself, which is known to us,
and whose crystals are either octahedrons inserted one
in the other, or cubes placed one upon each other slant-
wise.

2. The arsenical ore of antimony may be considered
as a true regulus by those who, after Bergmann, do not
admit of arsenic as a mineralizer : for the ore is then con-
sidered as an alloy of the two reguli.

This ore is as white as silver, and exhibits large facets
like antimony. The specimen was sent from Allemont
in Dauphiny, to Mr. Sage. Its gangue is quartz. Small
fasces of the grey and red ores of antimony striated and
radiated, and not containing arsenic, are sometimes found
in the cavities of this stone.

The antimony and the arsenic exist in the metallic state
in this ore. The arsenic adheres so strongly to the anti-
mony that it cannot be disengaged by torrefaction. Mr.
Sage combined the ore with sulphur, and obtained orpi-
ment and realgar. This mineralogist has concluded, from
his analyses, that the arsenic existed in the proportion of
sixteen pounds in the hundred.

3. Antimony is usually mineralized by sulphur, in
which combination it exhibits three or four very distinct
varieties. It is sometimes crystallized of a grey colour
inclining to blue. The crystals are very frequently slen-
der, oblong, hexahedral prisms, terminated by tetrahe-
dral pyramids. The mines which are wrought in Au-
vergne afford us beautiful prisms, of the same geometri-
cal form, but thicker than those of the antimony of Hun-
gary. These last crystals soon become of an irised co-
lour ; but those of the mines of Auvergne are not so
speedily changed. I possess a large specimen of anti-
mony from the neighbourhood of Alais, which is entirely
covered with crystals perfectly similar to those of Hun-
gary. It frequently happens that these crystals are con-

fused and indistinct, in which case the ore appears to be formed of very slender prisms applied sidewise to each other. That which is called plumose antimony does not differ from these varieties, excepting that its crystals are very slender and detached. They are usually of a blackish grey. This variety has been arranged among the ores of silver, because for the most part it contains that metal.

Ores of antimony have been found in several parts of France; but our province of Languedoc exhibits very curious specimens. We have them at Malbos in the county of Alais. This mineral has been wrought in the diocese of Uzes; but the want of consumption has prevented the works from going on with spirit. Mr. De Gensanne has observed in Vivarais a large vein of ore of antimony in a stratum of pit-coal.*

The decomposition of the sulphureous ore of antimony produces the red antimonial ore. The red ore more especially accompanies the specular antimony of Tuscany. Its surfaces appear to be corroded or rendered carious by decomposition; and when a piece is broken, it emits a powder which has the properties of kermes.

The decomposition of sulphureous antimony likewise produces the sulphate of antimony. Some varieties of these antimonial decompositions may likewise be seen in the Analyse Chimique of Mr. Sage.

Antimony is found in two states in the course of trade; namely, in the form of crude antimony, and in the metallic form.

Crude antimony is nothing else but the sulphureous ore of antimony cleared of its gangue. For this purpose the ore is put into pots pierced at the bottom, and disposed upon other pots buried in the earth. The uppermost pots which contain the mineral are then heated; the antimony becomes fused, and flows, together with its sulphur, into

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* It is said that antimony has been found in New-Jersey, and that a specimen was taken from a vein of that metal, at Sagherties, between Esopus and Kaatskill, in the state of New-York. It is reported to exist there in considerable quantity.*—*Am. Ed.*

* Medical Repository, Hexade 2, vol. iv, p. 304.

Drayton informs us, that it is also met with in the upper parts of South-Carolina.

the lower vessels, while the gangue remains in the upper
pots.

As the mixture of antimony, and sulphur is very fusi-
ble, this process may be varied in a thousand ways.   I
have myself wrought an antimonial ore with the greatest
œconomy, by fusing it in a furnace, over the arch of which
I had disposed the ore broken into pieces of five or six
pounds weight each.   The heat was communicated to the
whole mass by five openings in the arch or roof; and the
antimony, as it melted, ran down on the outside of the
furnace by means of channels cut in the convex part of
the dome.   This method afforded forty quintals of anti-
mony in twenty-seven hours, by the consumption of be-
tween twenty and thirty quintals of combustible matter.

We are acquainted with two methods of depriving crude
antimony of its sulphur.   1. The slow and gradual cal-
cination of the ore, which affords a grey oxide, and this
urged by a violent heat is converted into a reddish and
partly transparent glass of antimony.   It does not assume
this transparence unless it has been perfectly fused.   The
glass of antimony is a violent corrosive, but is capable of
being corrected by mixing or kneading it with yellow
wax, and afterwards burning of the wax; or otherwise
by triturating it with a volatile oil.   This is the cerated
antimony of Pringle, so much extolled in dysenteries.
2. Or otherwise, the antimony may be deprived of its
sulphur by projecting into an ignited crucible a mixture
of eight parts of crude antimony, six of tartar, and three
of nitre.   By keeping this mixture for a certain time in
fusion, the antimony is obtained in the metallic state.

In the large works antimony is torrefied in an oven re-
sembling that of the bakers.   Fifty pounds of dried wine
lees or tartar are mixed with a hundred pounds of the ox-
ide of antimony, and the mixture is then fused in proper
crucibles.   The metallic button contains the form of the
crucible; and these loaves of antimony exhibit a star on
their upper surface, which has been considered as pecu-
liarly characteristic; but is in fact nothing more than a
confused crystallization formed by octahedrons inserted
one in the other.

Copper, silver, and iron, when fused with the sulphure of antimony, seize its sulphur, and reduce it to the state of regulus. This has been distinguished by the name of the metal employed. Thus we hear of the regulus of Mars, of Venus, &c.

Antimony is difficult of fusion; but when once melted, it emits a white fume known by the name of Argentine Snow, or Flowers of Antimony. These fumes, when collected, form very brilliant prismatic tetrahedral crystals : Mr. Pelletier has obtained them in transparent octahedrons. The argentine flowers of antimony are soluble in water, which they render emetic. The volatility and solubility of this sublimed oxide exhibit a resemblance with the oxide of arsenic before treated of. We are indebted to Rouelle for these observations on the properties of this antimonial oxide.

Antimony is very slightly changed by exposure to air, in which it long preserves its brilliancy.

The specific gravity of fused antimony is 6,7021.— See Brisson.

The sulphuric acid, by slow ebullition upon this metal, is partly decomposed. Sulphureous gas first escapes, and sulphur itself is sublimed towards the end. When four parts of the acid are used with one of the antimony, the residue, after the action of the acid, consists of the metallic oxide, with a small quantity of the sulphate of antimony, which may be separated by means of distilled water. This sulphate is very deliquescent, and is easily decomposed in the fire.

The nitric acid is decomposed upon this semi-metal with great facility. It oxides a considerable part, and dissolves a portion, which may be suspended in water, and forms a very deliquescent salt, decomposable by heat. The oxide prepared by this means is very white, and very difficult of reduction. It is a true bezoar mineral.

The muriatic acid acts upon antimony only by a long digestion. Mr. Fourcroy has observed that this acid, long digested upon the metal, dissolves it; and that the muriate of antimony, obtained by a strong evaporation in the form of small needles, is very deliquescent. It is fusible in the fire, and likewise volatile. Mr. Monnet has proved that twelve grains of the oxide of antimony are

sufficient to saturate half an ounce of the ordinary muri-
atic acid. Messrs. Monnet and De Fourcroy have al-
ways found that there is a portion of the muriate of anti-
mony which is not volatilized by the fire : this depends
upon its being strongly oxided or calcined.

If two parts of the corrosive muriate of mercury, and
one of antimony, be distilled together, a very slight de-
gree of heat drives over a butyraceous matter, which is
called butter of antimony, or the sublimed muriate of an-
timony. It may be presumed that the acid in this com-
position is in the state of oxigenated muriatic acid, as it
is in the corrosive sublimate.

The sublimed muriate of antimony becomes fluid by
a very gentle heat ; and by virtue of this property it may
conveniently be poured from one vessel to another : for
nothing more is necessary than to plunge the bottle which
contains it into hot water, and the muriate may then be
poured out in its liquid state.

I have several times observed this muriate of antimony
crystallized in hexahedral prisms with dihedral summits :
two sides of the prism are inclined, and form that which
the ancient chemists distinguished by the name of cry-
stals in the form of a tomb. This muriate is used as an
escharotic. When the salt is diluted with water, a white
powder falls down, called powder of algaroth, or mercu-
rius vitæ. This powder does not contain an atom of the
muriatic acid, and is merely an oxide of antimony pro-
duced by that acid.

Simple water has some action upon this semi-metal ;
for we find that it becomes purgative by remaining in
contact with it. Wine, and the acetous acid, completely
dissolve it : but the emetic wine is an uncertain remedy ;
because it is impossible to determine with absolute cer-
tainty the degree of its energy, which depends upon the
very variable degree of acidity of the wine made use of.
The emetic wine ought not therefore to be used but in
external applications.

The gastric fluids likewise dissolve this semi-metal, as
is proved by the famous perpetual pills. This purgative
has been distinguished by the name of Perpetual Pills ;
because, being very little alterable, the pill may be trans-
mitted from generation to generation.

The acid of tartar forms a very well known salt with antimony, which is much employed in medicine under the name of Emetic Tartar, Stibiated Tartar, or simply E-metic. It is this salt which, in the New Nomenclature, is distinguished by the name of Antimoniated Tartrite of Potash.

In the examination of the various authors who have treated of the preparations of this remedy, as well as by comparing the most celebrated dispensatories, we do not find two which propose an uniform process which is constant and invariable in its effects.

Some prescribe the crocus metallorum, or semi-vitreous oxide of sulphurated antimony ; others the glass of antimony ; others the liver of antimony, or sulphurated oxide of antimony ; and others the sublimed oxide : some combine several of these substances. But all in general adopt cream of tartar, or the acidulous tartrite of potash, as a solvent.

The processes vary not only in the choice of the substances to be made use of, but even in the proportions in which they are to be employed. We likewise find varieties in the quantity of water used as a vehicle, which is not an indifferent circumstance ; in the time prescribed to digest the substances together, a circumstance of the greatest consequence to be ascertained, because the saturation of the acid depends absolutely and essentially upon it. The choice of vessels must likewise influence the effect of this remedy. Hoffmann has affirmed that the emetic lost its effect by a long ebullition ; and Mr. Baumé has proved that iron precipitates the antimony after a time, and consequently that the iron vessels prescribed in certain dispensatories ought to be rejected.

This variety in the processes must necessarily influence the result ; and we cannot be much surprised that Geoffroy, who analyzed several antimoniated tartrites of potash, should have found from thirty grains to two gross and ten grains of metal in the ounce of this salt.

Is it not therefore of great consequence to prescribe a uniform process, whose product should be invariable. These heroic remedies, which operate in small doses, ought to produce constant and invariable effects through all Europe. It would be much more advantageous that

solemn proceedings should be made for the preparation of
these active remedies, than for the composition of the the-
riaca, a true pharmaceutic monster, the dose of which
may with impunity be varied from a few grains up to three
hundred. It follows, from the variety of the effects of
these sovereign remedies, that consultations become almost.
ineffectual; because the physician prescribes according to
the effects of the remedies he is in the habit of using :
and the art of medicine becomes no better than a discou-
raging alternative of success and disappointment.

At Montpellier, the emetic acts in a dose of one or
two grains; but in other places it does not operate in a
less dose than ten or twelve : and the stibiated tartar sold
by those wholesale dealers in medicine, who supply the
country apothecaries, is usually nothing but the sulphate
of potash, or vitriolated tartar moistened with a solution
of emetic tartar. It is a thing greatly to be desired, that go-
vernment, which does not apply its stamp of approba-
tion to objects of luxury until they have passed a rigid
inspection, should prohibit traders from circulating with
impunity, products upon which the health of the citizen
so essentially depends. These are the frauds and decep-
tions which have engaged me to form an establishment of
chemical products, in which intelligence and probity pre-
side over all its operations; and I have succeeded in my
laboratories so far as to conduct the processes with suffi-
cient economy to afford products faithfully made up, and
invariable in their effects, at the same price as those so-
phisticated drugs with which the public has hitherto been
poisoned.

The most accurate process for making an excellent
emetic consists in taking very transparent glass of anti-
mony, grinding it fine, and boiling it in water, with an
equal weight of cream of tartar, until this salt is satu-
rated. By filtration, and evaporation with a gentle heat,
and subsequent repose, crystals of the antimoniated tar-
trite of potash are obtained, whose degree of emeticity
appears to be sufficiently constant. The crystals may be
obtained in several successive products by repeated eva-
porations.

Macquer proposed the powder of algaroth, as more
uniform in its power. Messrs. De Lassone and Durande

have adopted the opinion of Macquer; and the celebrated Bergmann has followed the ideas of the French chemists, with a few slight modifications.

Take five ounces of cream of tartar reduced into powder, and two ounces two gros of the powder of algaroth precipitated by hot water, washed and dried. Add water to these, and boil them gently. By filtration and evaporation the crystals of emetic tartar are obtained; which may be given in the dose of three grains, without fatiguing the stomach or intestines.

The antimoniated tartrite of potash crystallizes in trihedral pyramids. It is very transparent, is decomposed on the fire with crackling, and leaves a coaly residue. Sixty parts of water dissolve it. It effloresces in the air, and becomes farinaceous. The solutions of this salt throw down a mucilage, which fixes, and forms a pellicle of considerable thickness : it is the mucilage of cream of tartar, which is insoluble in water, and partly soluble in alcohol. The sulphuric acid blackens it, but does not itself become coloured till after a long time. The nitric acid dissolves it partly; and is itself decomposed, with the emission of much nitrous gas.

The alkalis and lime decompose the antimoniated tartrite of potash. Antimony, properly mixed with the nitrate, decomposes that salt completely. Equal parts of the semi-metal and nitre being thrown into an ignited crucible, the salt detonates, its acid is decomposed; and at the end of the operation the crucible is found to contain the alkali which served as the base of the nitrate, and the antimony reduced to the state of white oxide : this is called Diaphoretic Antimony. The same preparation may be made by using the sulphure of antimony; in which case three parts of the nitrate are used to one of the crude antimony. The residue in the crucible, after the detonation, is composed of the oxide of antimony, fixed alkali, a portion of the nitrate not decomposed, and a small quantity of sulphate of potash. This compound is still known by the name of the Solvent of Rotrou. Water deprives it of all the salts it contains; and leaves only the oxide of antimony, which is called Washed Diaphoretic Antimony. If a small quantity of acid be poured on the fluid which holds the salts in solution, a

small portion of the oxide of antimony falls down, which was dissolved by the alkali of the nitre. The precipitate forms the ceruse of antimony, or the pearly matter of Kerkringius.

Equal parts of the sulphure of antimony and of nitrate of potash, detonated in an ignited crucible, form the liver of antimony or sulphurated oxide of antimony; which, when pulverized and washed, produces the saffron of metals, or crocus metallorum.

The oxides of antimony have been considered as very difficult of reduction ; and it was not without surprise that I at first observed the facility with which they are all reducible by the black flux. This prejudice was established and propagated for want of proper experiments.

The alkalis do not sensibly act upon antimony : but the sulphures of alkali dissolve it completely ; and it is upon this principle that an operation is founded by which we obtain a valuable remedy, known by the name of Kermes Mineral, to distinguish it from the vegetable kermes used in dying. The preparation is simply a red sulphurated oxide of antimony. This remedy, first pointed out by Glauber, who made it with antimony and the solution of nitre fixed by charcoal, is indebted for its celebrity to the wonderful cures it performed in the hands of Simon, a Chartreux friar; whence it obtained the name of the Powder of the Chartreux. This religious man obtained the composition from a surgeon named Laligerie, to whom it had been given by Mr. Chastenay, lieutenant at Landau. Mr. Dodart, first physician to the king, bought the secret in the year 1720; and Mr. Laligerie rendered it public. According to his process, the pounded sulphure of antimony is boiled for two hours, with one fourth of its weight of the solution of fixed nitre or potash, in twice its weight of very pure water. After ebullition the fluid is filtered ; the kermes falls down as it cools, and is afterwards dried. Laligerie directs that more of the solution of fixed nitre be digested on the metal, till it is completely dissolved. Laligerie burned spirit of wine or brandy upon it. The liquor which remains after the kermes is fallen down, contains more kermes, which may be disengaged by means of an acid. This kermes, which is paler than the former,

is known by the name of Golden Sulphur of Antimony, or the orange-coloured sulphurated oxide of antimony.

This process is no longer used. That which succeeded the best with me, consists in boiling ten or twelve pounds of pure alkaline solution with two pounds of the sulphure of antimony. The ebullition is continued for half an hour, after which the fluid is filtered; and much kermes is obtained by mere cooling. I digest new alkali on the antimony, until it is consumed. The kermes which I obtain by this means is of a beautiful tufted appearance.*

Geoffroy, who analyzed the kermes in 1734 and 1735, found that one gros of kermes contained from sixteen to seventeen grains of antimony, from thirteen to fourteen grains of alkali, and from forty to forty-one of sulphur. But Messrs. Baumé, Deyeux, de la Rochefoucauld, and De Fourcroy, are convinced that the washed kermes does not contain an atom of alkali which is not necessary to its virtues.

Kermes is likewise one of those remedies in the preparation of which the greatest care ought to be taken. It is nevertheless a substance which all the apothecaries in the country buy at the fair of Beaucaire ; and the analysis which I have several times made of this kermes, has convinced me that it very often is nothing else but pounded brick, mixed with vegetable kermes, and sprinkled with a strong solution of emetic tartar. I have found some

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* Kermes Mineral is prepared by Goetling, in the following manner : Reduce separately to powder, and afterwards mix sixteen parts of crude antimony, twenty-four parts of purified potash, and three parts of flowers of sulphur ; introduce the mixture into a crucible, and let it enter into complete fusion. After it has cooled, pulverise the mass, and boil it for half an hour, in one hundred and twenty-eight parts of water ; filter it while boiling through a thick cloth, letting it run into an earthen pan, containing one hundred and fifty-six parts of water, and leave it exposed to the air in a shallow vessel for two or three days, or until particles of a bright orange colour appear on its surface. Afterwards decant the liquid, wash the deposite in a large quantity of water, then remove it on a filter, and complete the edulcoration ; when this is done, dry it by a gentle heat.

This process yields twelve or fourteen parts of the kermes, of a fine red brown colour ; the whole quantity of antimony, except a trifling residuum of extraneous matter, is dissolved and converted into kermes, and only a very small quantity remains in the decanted liquor, in the form of golden sulphur of antimony.—*Am. Ed.*

which was merely a mixture of the fine brown red and the calx of antimony.

Lime and lime-water, digested upon pulverised antimony, afford, even in the cold, at the end of a certain time, a kind of kermes, or golden sulphur of a beautiful red colour.*

Antimony enters into the composition of printers' types. It is likewise mixed with tin to increase its hardness. It was formerly used as a purgative: for this purpose it was made into cups, in which water or wine was suffered to stand for a night, and taken by the patient the following day.

The sulphure of antimony is used as a sudorific in skin disorders. For this purpose it is tied in a cloth, and digested in the ptisans appropriated to these disorders. It is administered in pills for the same purpose.

The solvent of Rotrou has been much used to dissipate lymphatic concretions, and pituitous swellings.

Washed diaphoretic antimony is used in considerable doses to excite perspiration. Some physicians have considered it as a medicine void of effect; and Boerhaave has maintained that its effect is not more considerable than that of Lemnian earth.

The kermes mineral is one of the most valuable medicines that the healing art is acquainted with. It is inci-

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* There is a celebrated quack medicine of great repute in England, known by the name of James's Powders. The analysis of this powder, made by Dr. Pierson some years ago, led the College of Physicians of London to adopt an antimonial preparation, as a proposed subsitute for the empiric medicine, which is termed the *pulvis antimonialis.* This is prepared by calcining together, first in a gentle and afterwards in an intense heat, equal weights of hartshorn shavings and crude antimony, so that the powder when prepared, is a mixture of phosphate of lime and oxide of antimony.

Mr. Chenevix has proposed the following method of preparing the same powder in the moist way, which will be more uniform in its quality, and perhaps made with greater ease.

Dissolve, together or separately, in the least possible portion of muriatic acid, equal parts of the white oxide of antimony, (procured by adding pure water to the butter of antimony) and of phosphate of lime. Pour this solution gradually in distilled water, previously alkalized by a sufficient quantity of caustic ammoniac. A white and abundant precipitate will take place, which when well washed and dried, is the substitute proposed for James's powder.—*Am. Ed.*

sive; and may be administered in all pituitous cases, when the stomach fails, and the lungs are obstructed. In a more considerable dose it is sudorific, and a still larger portion is emetic. It is employed in the dose of from half a grain to three.

The tartar emetic has received its name from its uses. It is dissolved in water; and this solution produces its effect.

The liver of antimony, crude antimony, and the crocus metallorum, are more especially used as purgatives in the veterinarian practice. They are given to horses in the dose of about an ounce..

CHAPTER VI.

Concerning Zinc.

ZINC is a metallic substance of a blueish brilliant white colour, very difficultly reducible into powder, but capable of being extended into very thin plates by the equal and gradual pressure of the flatting-mill. From this last property, which has been proved by Mr. Sage, we may consider zinc as the intermediate substance between semi-metals and metals.

Zinc is found naturally in various states.

1. Cronstedt affirms that he saw a radiated crystalliza- tion of a metallic appearance, which is found at Schnee- burg, where it is called flowers of bismuth, but which he found to be the regulus of zinc. This celebrated minera- logist does not venture to pronounce that it is native zinc.

Mr. Bomare affirms that he found it in small pieces in the mines of lapis calaminaris in the dutchy of Limbourg, and in the zinc mines of Goslar. This regulus may have arisen from the scoriæ of furnaces, or from the ancient works; so that the existence of native zinc is still consi- dered as very doubtful by these mineralogists.

2. Zinc is usually mineralized by sulphur, forming an ore known by the name of Blende, which in German sig-

nifies *blinding* or *deceitful;* a name which may have been given to it because such districts as abound with this mineral are barren of other ores.

The determinate crystallization of blende appears to be the alumini-form octahedron, and sometimes the tetrahedron; but the modification of these primitive forms are so numerous, that the crystals are found in an astonishing variety of figures. Most commonly they are polyhedral crystals of an indeterminate form, or scarcely capable of being described. On this circumstance depend the denominations of Blende with Large or Small Plates, Striated Blende, Compact Blende, and other species, which may be seen in the works of Messrs. Sage, De Lisle, &c.

The colour of these blendes is infinitely various; they are found yellow, red, black, semi-transparent, &c.

All the blendes emit an hepatic smell when grated or triturated.

There is a kind of blende which exhibits a line of phosphoric flame when scratched with a knife, or even with a tooth-pick. Mr. De Bournon found this yellowish, transparent, and phosphoric blende, similar to that of Scharffenburg, at Maronne in the mountains of Oisan, at the distance of nine leagues from Grenoble. The phosphoric blende contains scarcely any iron.

To make the assay of a blende, Mr. Monnet advises solution of the ore in aqua fortis. The acid unites with the metal, and separates the sulphur: after which the oxide of zinc may be obtained by distilling off the acid; and this may be reduced. Bergmann obtains one part of the sulphur of these ores by distillation, dissolves the residue in acids, and precipitates the metal from its solutions. Mr. Sage distils blende with three parts of sulphuric acid: the sulphur sublimes by this operation; and the residue in the retort is the sulphate of zinc, mixed with a small quantity of sulphate of iron, and other substances mixed with the Zinc. I do not know any country where blende is wrought to obtain the zinc: but it is sometimes mixed with lead; and in the working of this last metal the former is occasionally obtained. Such is the ore worked at Rammelsburg near Goslar, in the lower Hartz. Great part of the zinc is dissipated during the fusion of the lead ore; but a portion of this metal is obtained by a very ingenious process.

Care is taken to keep the anterior part of the furnace cool; against which a stone is placed with a slight degree of inclination. The vapours of the zinc which are carried against this stone, are condensed, and fall in drops into powder of charcoal ; with which a stone placed at the bottom is covered. The semi-metal is defended from oxidation by means of the charcoal ; and it is afterwards fused, and cast into convenient forms.

This zinc is always united with a small quantity of lead, and is less pure than that which comes to us from India, under the name of Tutenag.

I strongly calcined the blende of St. Sauveur, and mixed the powder with charcoal. I then put the whole into a retort whose orifice was plunged beneath water ; and by a violent heat, kept up for two hours, I obtained much zinc, which fell to the bottom of the water.

3. The decomposition of blende gives rise to the formation of the sulphate of zinc. The operation of nature is slow, but art has supplied its defect. All the sulphate of zinc which is met with in commerce, is prepared at Rammelsburg. For this purpose, after having roasted the galena mixed with the blende, it is thrown ignited into cisterns full of water, where it is left for twenty-four hours. The roasted mineral is three times extinguished in the same water ; after which the lixivium is evaporated, and put into coolers. At the end of fifteen days the water is decanted, in order to separate the crystals of the sulphate of zinc. These crystals are afterwards fused in iron vessels ; and the liquor is poured into coolers, where it is stirred till it congeals. We shall examine the properties of this salt in due course.

4. Zinc is likewise found in the state of oxide ; and it appears to me that nature makes use of two means of converting the metal to this state. 1. The sulphur is sometimes dissipated without the production of sulphate : in which case it is replaced by the oxigenous gas, and the result is that oxide of zinc which is known by the name of Lapis Calaminaris. I have found strata of lapis calaminaris, at St. Sauveur, intermixed with layers of blende; and the transition of the blende to the state of lapis calaminaris may be followed in the most interesting manner. 2. The sulphate of zinc produced by the decomposition

of blende in certain circumstances, is itself decomposed by calcareous stones. In the rich collections of Messrs. Sage, De Lisle, &c. we see crystals of calcareous spar converted into calamine at one end, and calcareous at the other.

Calamine crystallizes in rhomboidal tetrahedral prisms, or in hexahedral pyramids.

It is sometimes covered with protuberances; often has the appearance of being worm-eaten; and is, at other times, either spongy or compact.

Its colour varies greatly. The county of Somerset affords it of white, green, and other colours.

To make a good analysis of calamine, Bergman advises solution in the sulphuric acid; he obtains the sulphates of iron and of zinc. That of iron is decomposed by a known weight of zinc; and the metal is afterwards precipitated by the carbonate of soda. He has ascertained that ninety-three grains of this precipitate are equivalent to one hundred grains of zinc; and from this weight he deducts that of the zinc made use of to precipitate the iron.

Zinc may be obtained from calamine by distillation. For this purpose I have used the same process as has already been mentioned in treating of blende.

Zinc yields beneath the hammer, without extending itself. If it be cast into small plates, it may then be laminated, and reduced into very thin and very flexible leaves.*

The specific gravity of fused zinc is 7,1908. See Brisson.

Zinc, when heated, may be easily pulverized. This operation is very difficult without this precaution indicated by Macquer; for it wears and chokes up files, and destroys them in a short time: besides which, they have no considerable action upon it. It may likewise

* Zinc is a malleable metal at a temperature between 210° and 300° of Fahrenheit's thermometer. It yields to the hammer and may be drawn into wire, if kept at this temperature during the operation. They say, that after being annealed and wrought, it continues soft, flexible and extensible, and does not return to its partial brittleness, but may be bended and applied to many uses for which it has been hitherto thought unfit.—*Am. Ed.*

be fused and poured into water.—These are the most
convenient means of pulverizing it.

Zinc, treated in close vessels, sublimes without de-
composition: but when it is calcined in the open air, it
becomes covered with a grey powder, which is a true
oxide ; and, if it be heated to redness, it takes fire, emits
a blue flame ; and white flocks issue from it, which are
called Philosophical Wool, Pompholix, or Nihil Album.
This oxide may be fused into glass by an exceedingly
violent heat: the glass is of a beautiful yellow colour.
Zinc laminated into very thin leaves, takes fire by the
flame of a taper, and burns with a blue colour mixed
with green.

Mr. De Lassone, who has written several excellent
Memoirs on zinc, considers it as a kind of metallic
phosphorus.

Water appears to have some action upon zinc. When
this semi-metal begins to be ignited, if water be poured
on it, the fluid is decomposed, and much hydrogenous
gas is disengaged.   Messrs. Lavoisier and Meuisner
have ascertained this fact, in their fine experiments on
the decomposition of water.

Sulphuric acid dissolves it in the cold, and produces
much hydrogenous gas.   A salt may be obtained by eva-
poration, in tetrahedral prismatic crystals, terminated by
a four-sided pyramid.   Mr. Bucquet has observed that
these prisms are rhomboidal.   This salt is known by the
name of Vitriol of Zinc, White Vitriol, Sulphate of Zinc :
its taste is considerably styptic.   It is not much altered
by exposure to air when pure ; but suffers its acid to
escape, at a degree of heat less than is required by the
sulphate of iron.*

* The crystallized acetite of zinc is considered as one of the best
applications, in all cases of gonorrhæa.

For the purpose of an injection, eight or ten grains are dissolved
in four or six ounces of water, or in a thin mucilage of quince seed,
or a decoction of linseed or barley, increasing or diminishing it in
strength, so as to excite a slight smarting. The following is the best
method of preparing it. To a solution of the sulphate of zinc, in
eight times its weight of water, add a solution of acetite of lead, in
twice its weight of water, as long as any precipitation ensues, or a
little longer, in order to insure the complete decomposition of the
white vitriol.   Throw the whole upon a linen strainer, and wash off
the soluble part by repeated affusions of distilled water.—*Am. Ed.*

The nitric acid attacks zinc with vehemence, even when diluted with water. In this operation a great part of the acid is decomposed; but if the residue be concentrated by slow evaporation, crystals are obtained in compressed and striated tetrahedral prisms, terminated by pyramids with four sides. Mr. De Fourcroy, to whom we are indebted for this observation, adds, that the salt melts upon heated coals, and spreads abroad with decrepitation, and a small reddish flame. If it be exposed to heat in a crucible, it emits red vapours, assumes the consistence of a jelly, and preserves this softness for a certain time. The nitrate of zinc is very deliquescent.

The muriatic acid attacks zinc with effervescence. Hydrogenous gas is produced, and black flocks are precipitated, which some chemists have taken for sulphur, others for iron, and which Mr. De Lassone considers as an irreducible oxide of zinc. This evaporated solution becomes thick, and refuses to crystallize. It suffers a very concentrated acid to escape when heated, and the muriate itself sublimes by distillation.

The pure alkalis boiled on zinc obtain a yellow colour, and dissolve a part of the metal, as Mr. De Lassone has proved. Ammoniac digested in the cold upon this semi-metal, disengages hydrogenous gas: this evidently arises from the decomposition of the water, which alone, and without any mixture, is decomposed upon ignited zinc, as we have already observed.

Zinc mixed with the nitrate of potash, and thrown into an ignited crucible, causes this salt to detonate strongly.

Zinc decomposes the muriate of ammoniac by simple trituration, according to Mr. Monnet.

Pott has observed that a solution of alum, boiled upon the filings of zinc, is decomposed, and affords the sulphate of zinc.

Zinc fused with antimony, forms a hard and brittle alloy.

It unites with tin and copper, and forms bronze; when combined with copper alone, it forms brass.

It is mixed with gunpowder, to produce the white and brilliant stars of artificial fire-works.

It has been proposed to substitute this metal in the room of tin, for the internal lining of copper vessels;

and it is ascertained from the labours of Mr. Malouin, that this covering would be more uniformly extended upon the copper, and would be harder than tin. It has been remarked that vegetable acids might dissolve it, and that these salts are dangerous; but Mr. de la Planche has made all the experiments on this subject which his extensive knowledge and zeal for the public good, could inspire; and he is convinced that the salts of zinc, taken in a more considerable dose than the aliments prepared in vessels tinned with this semimetal might contain, are not dangerous.

The sublimed oxide of zinc is much employed by the German physicians under the name of Flowers of Zinc. This remedy is given as an antispasmodic. It may be administered in pills, in the dose of one grain. Tutty, or pompholix, is mixed with fresh butter, as an excellent remedy in disorders of the eyes.

Mr. De Morveau has substituted the precipitate of zinc to white lead, in painting with the greatest advantage. It perfectly answers the intention of the artist, and is not attended with any dangerous consequences in its use*.

CHAPTER VII.

Concerning Manganese.

A MINERAL of a grey or blackish colour, soiling the fingers, and used in glass-houses under the name of Soap of the Glass-makers, has been long known in commerce. Most naturalists, such as Henckel, Cramer, Gellert, Cartheuser, and Wallerius, have placed it among the iron ores. Pott and Cronstedt did not consider it as a ferruginous substance. The latter found it to contain tin; and Mr. Sage was long of opinion that it was an intimate alloy of zinc and cobalt.

* It will not answer in the place of white lead, as it does not dry so soon.—*Am. Ed.*

The celebrated Bergmann, in the year 1764, declared in print, that black manganese ought to contain a pe- culiar metal; but he attempted in vain to extract it. However, Mr. Gahn, a physician at Stockholm, suc- ceeded in obtaining a metal by the assistance of an ex- ceedingly strong fire.   We shall explain his process after having spoken of the different forms under which manganese is found in the earth.

Manganese appears to be always found in the state of oxide; but this oxide exhibits several varieties.

1. It is sometimes grey, brilliant, and crystallized, formed of very slender prisms confusedly intertwined, and resembling the ore of antimony; from which how- ever it may be easily distinguished by exposing it upon charcoal.   For antimony fuses, and affords vapours; but the manganese remains unchanged.

The crystals of manganese are striated, tetrahedral, rhomboidal prisms, terminating in four-sided pyramids. They frequently diverge from a centre.

2. Manganese is very often black and friable.   This species is found in the cavities of the brown hæmatites of the Pyrenean Mountains.

I have discovered an ore at St. Jean de Gardonen- que, in the Cevennes.   It is prodigiously light, is found in strata, and in pieces which almost always have the figure of an hexahedral prism, eighteen lines in length, and thirteen or fourteen in thickness.

This ore, upon which I have made experiments that I shall presently recite, is the purest and finest I am acquainted with.*

* Manganese of an excellent quality, is found in Northampton coun- ty, Pennsylvania.   Its specific gravity at the temperature of 62° of Fahrenheit's thermometer, and before it had absorbed water was 3.4193.   After (and the absorption accelerated by thirty minutes boiling in water) it rose to 3.7667.

Two ounces of it reduced to powder, heated in an iron tube, in one of Lewis's black lead furnaces, yielded eighty cubic inches of oxigen- ous gas, which tested by phosphorus, in the eudiometer of Fontana, left behind about three per cent. of azotic gas.

One measure of this oxigene gas, passed up over lime water, gave a portion of carbonate of lime, barely perceptible.

One ounce measure of muriatic acid, heated upon one ounce by weight of it over water, afforded forty-five cubic inches of

3. Manganese is sometimes of a reddish white colour, and composed of groups of protuberances. Its fracture is lamellated. That of Piedmont frequently has a grey, reddish tinge, and appears to be composed of small plates. It gives fire with the steel.

The manganese of Macon in Burgundy is of a deeper grey than that of Piedmont.

That of Peregueux is intermixed with yellow martial ochre. It is found in separate bodies and not in veins like that of Piedmont.

4. Most of the white spathose iron ores contain manganese, and may be considered as ores of this semi-metal. Manganese is likewise mixed with calcareous spar, gypsum, jasper, hæmatites, &c. Mr. De la Peyrouse has described thirteen varieties of crystallized manganese found in the Pyrenean Mountains.—See the Journal de Physique, Jan. 1780, p. 67.

5. Scheele has proved that the ashes of vegetables contain manganese; and it is to this mineral that the colour of calcined potash is owing. To extract it, three parts of fixed alkali, one of sifted ashes, and one-eighth of nitrate, must be fused together. The fluid mixture must then be poured into an iron mortar, where it congeals into a greenish mass. This being pounded, and boiled in pure water, must be filtrated, and saturated with sulphuric acid. At the end of a certain time, a brown powder is deposited, which possesses the properties of manganese.

To reduce manganese to the metallic state, a crucible is lined with charcoal; and into a hole made in this charcoal, a ball of manganese, previously kneaded with oil and gum ammoniac, is to be put; after which the hole is to be covered with powder of charcoal. Another crucible must then be fitted on, and the vessels exposed to a violent fire for an hour and a half. By following this

oximuriatic acid in which leaf copper, commonly called *Dutch-metal*, immediately inflamed.

Like all the other ores of manganese, it is combined with iron, silecious earth, &c. A deep blue precipitate takes place, upon adding the prussiate of potash to a solution of it in the muriatic acid.

Manganese is likewise found in the state of Virginia, and I have a specimen in my possession, picked up near Lancaster, Pennyslvania.—*Am. Ed.*

process, I have several times obtained the metal from the oxide of manganese of Cevennes. I have even succeeded in reducing it, by simply putting the powder of manganese into a lined crucible.

The button which is obtained almost always has asperities on its surface. Globules appear which scarcely adhere to the mass; and these portions are usually of a considerably deep green, while the internal part has a blueish cast.

This metal is more infusible than iron. I have several times observed, when the fire has not been sufficiently strong to fuse the manganese, that several globules of iron have appeared dispersed through the agglutinated oxide.

Saline fluxes ought to be rejected, as insufficient for this reduction. The great disposition which this semimetal has to become vitrified, causes it to be dispersed in the flux, where it remains suspended. I have several times, by using the vitreous flux of Mr. De Morveau, obtained metallic grains forming a button, or else dispersed in the flux; which, when more narrowly examined, proved to be nothing but iron, cobalt, or other metals, according to the nature of the ore of manganese. I have sometimes obtained even globules of lead; because the coarsest glass in which the presence of that metal is the least suspected, and which enters into the composition of the flux of Mr. De Morveau, contains it very often.

The specific gravity of manganese has been estimated by Bergmann, in proportion to that of water, nearly as 6850 to 1000.

The oxide of manganese, when strongly heated in close vessels, affords a prodigious quantity of oxigenous gas, and begins to afford it at a degree of heat less than is necessary to disengage it from the oxides of mercury: a strong fire is required to disengage the last portions. Four ounces of the manganese of Cevennes afforded me nine pints of oxigenous gas. The residue in the retort was a grey oxide; one part of which was incrusted in the fused glass, and had communicated to it a very rich violet colour.

The oxide of manganese, distilled with charcoal, affords the carbonic acid :* but, if it be calcined in an open vessel, it is reduced into a grey powder, which loses considerably of its weight when the fire is very strong ; and at length agglutinates, and forms a green mass.

If it be mixed with charcoal, it does not suffer any perceptible change in its colour.

Manganese, exposed to a very violent heat, vitrifies, and affords a glass of an obscure yellow colour. The iron which is mixed with it preserves its metallic form.

Manganese is easily changed in the air, and is resolved into a brown powder of a greater weight than the semi-metal itself ; a certain proof of oxidation.

Manganese unites easily by fusion with all the metals except pure mercury. Copper alloyed with a certain quantity of manganese is still very malleable.

If a mixture of the phosphate of urine with a small quantity of oxide of manganese be placed upon charcoal, and be kept in fusion for a few instants by means of the blue interior flame of the blow-pipe, a transparent glass will be produced, of a blue colour inclining to red ; which, when charged with a certain quantity of the salt, assumes the colour of a ruby. If it be kept in fusion for a longer time, a slight effervescence is perceived, and all the colour disappears. If the transparent globule be then softened by the exterior flame, the colour soon returns, and may be again effaced by keeping up the fusion for a time. The smallest portion of nitrate, added to the glass, immediately restores the red colour ; and, on the contrary, it is destroyed by the addition of sulphuric salts. This globule of glass, taken from the charcoal, and fused in the spoon of perfect metal, becomes red, and changes no more. These experiments were made by the celebrated Bergmann.

The sulphuric acid attacks manganese, and produces hydrogenous gas. This metal is dissolved more slowly than iron ; a smell is disengaged similar to that which is afforded by the solution of iron by the muriatic acid. The solution is as colourless as water, and affords by evaporation transparent colourless crystals in the form of parallelopipeds, and of a bitter taste. Mr. Sage obtained

* It yields carbonic acid gas and oxide of carbone.—*Am. Ed.*

them in tetrahedral prisms, terminated by four-sided py-
ramids. This salt effloresces in the air.

If the sulphuric acid be poured on the oxide of man-
ganese, and its action assisted by a gentle heat, an asto-
nishing quantity of oxigenous gas is disengaged. The
oxide of manganese of Cevennes afforded me five pints
and a half per ounce. When this oxide is deprived of
its oxigene, the residue is a white powder, soluble in wa-
ter, which by evaporation affords the sulphate of manga-
nese, already described.

The celebrated Bergmann has observed that coaly mat-
ter, such as sugar, honey and gum, assisted the action of
the acid. This depends on the combination of the oxi-
gene with these agents, to form the carbonic acid; and
the sulphuric acid acts more easily upon the metal itself.

Manganese is precipitated from its solutions by the al-
kalis, in the form of a whitish gelatinous matter; but
this precipitate soon loses its colour, and becomes black
by the contact of the air. This phenomenon, which I
have myself been a witness to, can be attributed, in my
opinion, only to the absorption of oxigenous gas: and I
was convinced of this truth by agitating the precipitate in
bottles filled with this gas; for in this situation the black
colour is produced in one or two minutes, and a consi-
derable part of the gas is absorbed. I have constructed
an eudiometer as certain and as invariable as that which the
liquid sulphure of potash, or solution of liver of sul-
phur, affords; but a large quantity of precipitate is re-
quired, which must be agitated against the sides of the
vessels, in order that it may present a greater surface to
the air, and that the absorption may be more speedy. I
judge of the absorption by causing the vessel to commu-
nicate, by a graduated tube, with standing water. The
ascension of this water in the tube is proportioned to the
volume of oxigenous gas absorbed.

The nitric acid dissolves manganese with effervescence.
There always remains a black, spongy, and friable body,
which exhibited to Bergmann all the characters of molyb-
dena. Other solvents presented a similar residue. The
solution of the nitrate of manganese has frequently a dull
colour, and assumes the red colour with difficulty. This
solution does not afford solid crystals, even by slow eva-
poration.

The oxides of manganese are soluble in the nitric acid. It is observable that this acid is not decomposed upon them, because it finds the metal in the state of oxide. Carbonic acid is afforded when coaly substances are added to assist the solution.   When the nitrous or fuming nitric acid is used, the solution is made without the assistance of these coaly substances, because the excess of nitrous gas seizes the oxigene of the oxide.   These solutions do not crystallize.

The muriatic acid dissolves manganese; but when it is digested upon the oxide it seizes the oxigene, and passes in vapour through the water.   This vapour is known by the name of Oxigenated Muriatic Acid, whose properties we have already explained.

The residue in the retort consists of a portion of acid combined with the manganese.   This by evaporation affords a saline mass, which attracts the humidity of the air.

The fluoric acid with manganese affords a salt of sparing solubility, and this acid dissolves but little of it : but by decomposing the sulphate, the nitrate, or the muriate of manganese by the fluate of ammoniac, a fluate of manganese is precipitated.   The same phenomenon takes place with the phosphoric acid.   The acetous acid has but a weak action upon this substance.   If it be digested upon the oxide of manganese, it acquires the property of dissolving copper, and forms the beautiful acetate of copper, or crystals of Venus; whereas the same acid, digested on copper, forms verdigris, or simply corrodes it.   This circumstance proves that the acetous acid becomes charged with oxigenous gas, by the assistance of which it dissolves the copper.

The oxalic acid not only dissolves manganese, but likewise the black oxide of manganese.   The saturated solution deposites a white powder, if there be not an excess of acid.   This salt is blackened by the fire, but easily resumes the milky colour in the same acid.   The oxalic acid precipitates it in the form of small crystalline grains, when poured into solutions made by the sulphuric, nitric or muriatic acids.

The acidulous tartrite of potash dissolves the black oxide, even in the cold.   The tartrite of potash added

to any solution whatever of manganese, occasions a pre-
cipitate which is a true tartrite of manganese.

The carbonic acid attacks manganese and the black
oxide. The solution becomes covered in the open air
with a pellicle, which consists of manganese that is
separated and oxided. It is white when it does not con-
tain iron.

If the muriate of ammoniac be distilled with this oxide
of manganese, an elastic fluid is disengaged, according
to the observation of Scheele, which he considers as
one of the principles of ammoniac, without determin-
ing its nature. Mr. Berthollet has proved that, when
ammoniac is disengaged by a metallic oxide, there is a
portion decomposed. The oxigene of the oxides unites
to the hydrogenous gas of the alkali to form water,
and the nitrogene gas escapes.

Eight parts of oxided manganese take up, by a gen-
tle heat, in a glass retort, three parts of sulphur;
and produce a mass of a greenish yellow colour,
which acids attack with an effervescence and hepatic
smell.

Manganese itself does not appear to combine with
sulphur.

In order to separate iron from manganese, the alloy
must be dissolved in the nitric acid, and evaporated to
dryness. The residue must be strongly calcined, and
digested with weak nitric acid, and a small quantity of
sugar. The acid takes up the manganese, which may
be precipitated by the carbonate of potash.

The alloy may likewise be put into a solution of the
sulphate of iron. The acid abandons the iron to unite
with the manganese.

The iron having less affinity with the acid than the
manganese, may likewise be precipitated by a few drops
of alkali.

The oxide of manganese, is chiefly used in glass-
houses, to deprive glass of its green or yellow colour,
which soda and sand, when fused together, usually as-
sume. It has on this account been called the Soap of
the Glass-makers. It is also used to colour glass and
porcelain of a violet colour.

The consumption of this mineral is become more con-
siderable since the discovery of the oxigenated muriatic
acid, which has pointed out its uses in bleaching of linen,
cotton, &c.

CHAPTER VIII.

Concerning Lead.

LEAD is the softest, the least tenacious, the least
sonorous, the least elastic, and one of the most
ponderous, of metals.   A cubic foot of lead weighs se-
ven hundred and ninety-four pounds, ten ounces, four
gross, forty-four grains.   Its specific gravity is to that of
water as 115523 to 10000. according to Brisson.   Its
fracture is of a blueish white colour, darker than that of
tin, and tarnishing in the air.   It possesses a peculiar
smell, which is rendered perceptible by friction.

A gentle heat is sufficient to fuse lead ; and the abbé
Mongez obtained it in crystals of the form of quadran-
gular pyramids, recumbent on one side.   Some authors
affirm that lead is occasionally met with in the na-
tive state.   Wallerius mentions three pieces of this
kind.   The German mineralogists likewise affirm that it
has been found native in Villach in Carinthia.   Mr.
Genssane found in Vivarais, in four places, at Sereme-
janes, at Fayet near Argentiere, at St. Etienne de Bou-
logne, and near Villeneuve de Berg, " grains of native
" lead, from the size of a chesnut to an almost impercep-
" tible degree of smallness; they are all included in a very
" ponderous metallic earth, which is precisely of the co-
" lour of the ashes of beech, or of litharge reduced to
" an impalpable powder.   This earth may be cut with a
" knife, but requires the hammer to break it."   He found
pieces which contained a substance similar to litharge in
their internal part.

Linnæus speaks likewise of a native lead in crystals.—
Most naturalists agree to consider native lead as of a very
problematical existence.   The various samples found in
cabinets are probably owing to ancient mine works. Time

has changed their appearance, and incrusted them with various matters, which seem to prove that they do not owe their formation to the action of fire; and this is the circumstance which may have imposed on certain naturalists.

1. Lead is usually mineralized by sulphur; and this ore is known by the name of Galena.*

It usually crystallizes in cubes, and in all the varieties of that figure.

Galena is distinguished into several species. 1. Large diced galena. 2. Small diced galena. 3. Scaly or plated galena. 4. Compact galena, in small brilliant grains resembling steel. It does not appear to be lamellated.

These distinctions are more especially necessary to be attended to, because the species are very different in richness, and the alloy of silver, which is inseparable from galena. In general, the large diced galena is poor in silver, and is used to give a glaze to pottery, by the name of Alquifoux, or potters' lead ore. That which is in small grains is richer, and is wrought as a lead ore containing silver.

Galena is the only species of lead ore which is worked; and we shall relate all we have to say concerning the working and assay of lead ores after having spoken of the other ores.

2. Lead has been found mineralized by the sulphuric acid. Mr. Monnet has called this ore the pyritous lead ore. It is friable, dull, black, and almost always crystallized in very long needles, or in stalactites. It effloresces in the air, and affords a true sulphate of lead. This appears to be of the nature of galena; for as the sulphate is not developed but by the efflorescence of the ore, it may be concluded that the sulphuric acid does not exist in the virgin ore itself.

* Lead ore is found on the Great Kenhaway, opposite to the mouth of Cripple creek, in the county of Montgomery, in Virginia. Sixty tons of lead have been made at this place in one year. It is also met with on the Catawba lands, and in Pendleton district, South Carolina; on Perkiomen creek about sixteen miles from Philadelphia. One hundred weight of this lead, contains 2 and $\frac{1}{3}$ ounces of silver. The greatest lead mines in this country, are in Louisiana and on the Mississippi.—*Am. Ed.*

Lead mixed with iron is sometimes combined with the sulphuric acid. A large quantity is found in the island of Anglesea. It cannot be reduced upon charcoal with the blow-pipe, but it fuses into a black glass.—Dr. Whitering has indicated this ore.

3. The carbonic acid very often mineralizes lead, and exhibits some varieties which we shall proceed to describe.

A. The white lead ore.—This is almost always found in the cavities of decomposed galena, or in the veins of powdery stone containing galena. It is heavy, and frequently of a greasy colour; decrepitates in the fire; and is easily reduced by distillation, affording only water and the carbonic acid. Its form is almost always crystalline, but varies prodigiously. The primitive form appears to be a dodecahedron, with isosceles triangular planes.

I have seen crystals accurately of the form of a hexaderal prism sometimes terminated by a six-sided pyramid. The ores of St. Sauveur in the Cevennes have afforded us this variety; Mr. Sage possesses white lead ore of Geroldseck crystallized in cubes.

White lead as transparent as flint glass has been found in England and in Siberia.

The analysis of the white lead of Siberia afforded Mr. Macquart, per quintal, sixty-seven parts lead, twenty-four carbonic acid, six oxigene, and three water.

B. Green lead ore.—This differs from the foregoing only in the modifications produced by the colouring principle, which is copper, according to Spielman; and iron, according to the greatest number of chemists. Its form is usually that of a truncated hexahedron; and this ore is not so easily reduced as the white ore.

C. The black ore of lead.—Lead may return to the state of galena by resuming the sulphur it had lost; and this regeneration is not rare. It is enough that any hepatic vapour should strike the ore to effect this conversion. The ores of Tschopau in Saxony, and those of Huelgoet in Lower Britanny, exhibit fine instances of this phenomenon.

The gradations or intermediate specimens of these different ores, establish an infinite number of species, which the naturalist can never admit but as varieties. The transition of the white lead ore to the black ore exhibits gradations of colour which it would be very superfluous to describe.

In the year 1766, Mr. Lehmann described a new species of lead ore, called Red Lead. It was found in Siberia, in the environs of Catherineburg. Its crystals are grouped, and adherent to quartz, to copper ores, or iron; and sometimes to galena, with crystals of white and green lead. It is frequently crystallized in rhomboidal tetrahedral prisms, short, and truncated obliquely.

Mr. Sage has considered this lead ore as a variety of the preceding species, coloured by iron, of which Mr. Lehmann has proved the existence. The abbé Mongez thinks it is mineralized by the arsenical acid.

Mr. Macquert has given us the most valuable information respecting the red lead ore; and has proved by an accurate analysis that it contains, in the quintal, lead thirty-six, oxigene thirty-seven, iron twenty-five, and alumine two.*

4. The phosphoric acid has likewise been found naturally combined with lead. This ore, discovered by Gahn, owes its green colour to iron. It does not effervesce with acids. In order to assay it, it must be dissolved in the nitric acid by the assistance of heat, and the lead may then be precipitated by the sulphuric acid. The supernatant liquor being decanted off, and evaporated to dryness, affords the phosphoric acid.

This ore melts by the blow-pipe, and affords an opaque globular mass without reduction. Its habitudes with fluxes resemble those of lead and its oxides.

Mr. De la Metherie has informed us that Mr. * * *, an English gentleman, by treating lead ores with the blow-pipe, had observed that there was one whose glo-

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* Minium in a native state has been discovered by Mr. Smithson Tennant, in a vein of Galena, in Devonshire, England. A portion of this substance was found in the centre of a piece of cubic Galena, accompanied with crystals of spar.—*Am. Ed.*

bulk crystallized by cooling, after having been in perfect
fusion; and that these ores were not reducible by the
blow-pipe.   He suspected they were mineralized by the
phosphoric acid.   Mr. De la Metherie and this gentleman
took seven ounces of the green lead ore of Hoffsgruard,
near Fribourg in Brisgaw; which, when treated by the
foregoing process, afforded them phosphoric acid.   The
phosphoric acid combined with minium afforded them a
green compound.

The decomposition of the ores which we have de-
scribed frequently affords the oxides of lead, or calciform
ores.

These oxides at first afford a powder which, being car-
ried along by waters, often mixes with argillaceous, cal-
careous, or quartzose earths.

These oxides vary more particularly in their colour,
which assimilates them more or less perfectly to ceruse,
massicot, or minium.

In order to make the assay of a galena, it must be pul-
verized and torrefied.   The torrefied mineral, mixed
with three parts of black flux, affords by fusion a metal-
lic button, which indicates the proportions of the lead in
the quintal of the ore.

Bergmann proposes to make the assay of sulphureous
lead ores by the nitric acid, which dissolves the lead and
not the sulphur.   The solution is then to be precipitated
by the carbonate of soda; and one hundred and thirty-
two grains of the precipitate are equivalent to one hun-
dred of the metal.   If the ore contains silver, ammoniac
is to be digested on the precipitate, from which it dis-
solves the oxide of silver.

The various operations to which lead ore is subjected
to obtain the lead, are—1. It is sorted, to separate the
rich or pure ore from the pulverized matter, and the
gangue which contains no metal.   2. The ore is pulve-
rized, and its gangue separated by washing.   3. The ore
is roasted in a reverberatory furnace, with occasional agi-
tation, that it may present all its surfaces to the air; and
when the external part begins to assume the form of a
paste, it is covered with charcoal, the mixture is stirred,
and the heat increased.   The lead then runs on all sides,
and is collected at the bottom of the furnace, which is

pierced, and permits the metal to flow into a receptacle properly defended by a lining of charcoal.

The scoriæ, which still retain much lead are fused by a blast furnace: the lead is cast into pigs for sale.

To disengage the silver which the lead may contain, it is carried to the refining furnace; where, by the united energy of fire, and the wind of bellows directed upon the melted lead, the metal is converted into a yellow scaly oxide, called Litharge. This litharge is driven off in proportion as it forms; and the silver remains alone in the middle of the cupel. The colour causes a distinction of the litharge into litharge of gold, or litharge of silver. When the litharge is fused in contact with charcoal, it resumes its state of metal; and the lead is so much the better, in proportion as it has been deprived of the silver it contained. The smallest alloy of fine metal renders it brittle.

Lead is fusible by a gentle heat. If it be kept for some time in fusion, it becomes covered with a grey oxide; which, when exposed to a more violent heat capable of keeping it ignited, assumes a deep yellow colour, in which state it is called Massicot. Massicot may be converted into the red oxide, or minium, by the following process. When the lead is converted into massicot, it is thrown out and cooled by pouring water upon it; after which it is carried to the mill, and ground into very fine powder, which is washed in water. The particles of lead which could not be pulverized in the mill, remain in the vessel where the washing is performed.

This oxide of lead is spread out upon the hearth of the furnace in which it is calcined. Lines are drawn on its surface; and it is stirred from time to time, that it may not clot together; and the fire is kept up for forty-eight hours. When the minium is taken out of the furnace, it is put into large sieves of wood, and passed through very fine net work, or cloth of iron wire, placed over the casks which receive the minium. We are indebted to Messrs. Jars for this information, who have given very curious details respecting the manufactories of minium in the county of Derby.

Mr. Geoffroy was of opinion, that, in order to form minium, no greater heat was required than one hundred

and twenty degrees of Reaumur's thermometer.   But this heat is not adapted to works on a large scale ; for in these the roof of the furnace is kept at a red heat.   The lead increases in weight ten per cent. by the calcination.

All these oxides, urged by a stronger heat, are con- verted into a yellow glass, so very fusible, that it pene- trates and destroys the best crucibles.   It is used in glass- houses, on account of its fusibility, not only to assist the fusion, but likewise to render the glass softer, more pon- derous, of a more unctuous feel, and more susceptible of being cut and polished.   These are the reasons for which it is made a part of the composition of flint glass, and crystal glass.

The oxides of lead, distilled without addition, afford oxigenous gas by a violent heat.—Priestley obtained it from minium, part of which was converted into globules of metal.*

When these oxides are fused with coaly matter, the metal becomes revived.

The sulphuric acid boiled upon lead affords much sul- phureous acid ; and an oxide is formed, which arises from a combination of the oxigene of the acid with the lead. A portion of the lead is nevertheless dissolved ; for if a sufficient quantity of water be poured on the residue, a very caustic salt is obtained by evaporation, in tetrahedral prisms, soluble in eighteen times their weight of water. This sulphate is decomposed by fire, lime, the alkalis, &c.

Very hot sulphureous acid, poured into a leaden ves- sel, corrodes and destroys it instantly.

The concentrated nitric acid is readily decomposed upon lead, and converts it into a white oxide ; but when the acid is weak it dissolves the metal, and forms crystals of an opaque white, in the form of segments of a three-sided prism.   I have specimens of the nitrate of lead in my la- boratory, which possess the form of truncated hexahedral prisms ; three of the sides being broader than the others,

* The best method of procuring oxigenous gas from minium is to put it into a glass retort ; cover it with sulphuric acid, and apply the heat of an Argand lamp.   Oxigenous gas, obtained in this manner, is contaminated with carbonic acid gas and sulphureous gas, which may be separated from it by washing the airs in water.—*Am. Ed.*

and exactly similar to those which Mr. De Fourcroy ob-
tained by insensible evaporation.

This salt decrepitates in the fire, and is fused with a
yellowish flame upon ignited coals. The oxide of lead
becomes yellow, and is reduced into globules of metal.
Sulphuric acid takes lead from the nitric acid.

The muriatic acid, assisted by heat, oxides lead, and
dissolves a portion. This salt crystallizes in striated hex-
ahedral prisms.

This muriate is slightly deliquescent. Lime and alka-
lis decompose it.

The same acid poured on litharge decomposes it in-
stantly. Fifty or sixty degrees of heat are produced.
The solution affords fine octahedral crystals, of an opaque
white colour, a styptic taste, and of very considerable
weight.

This salt decrepitates on the coals; and when the fire
is increased, its water of crystallization escapes, and it
becomes converted into a mass of a beautiful yellow co-
lour.

Three parts of water, at fifteen degrees of temperature
dissolve one part; and boiling water more than its weight.

The pure alkalis precipitate it in the form of a magma,
which occasions a kind of miraculus mundi.

The affinity of the muriatic acid with the oxide of lead
is so strong, that it is capable of decomposing all its com-
binations. Minium or litharge decomposes the muriate
of ammoniac. The same oxides, triturated with marine
salt, separate the soda; and it is upon these facts that
Mr. Turner and others have established manufactories for
procuring soda by the decomposition of marine salt.*

The muriates of lead, calcined or fused, afford a
pigment of a beautiful yellow colour. The manu-

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* I do not hear that soda has been separated from common salt by
a method sufficiently cheap for the purposes of commerce. It is
universally understood that Mr. Turner's profits arise from the sale
of the combination of muriatic acid with the lead, which forms the
yellow pigment known in London by the name of Patent Yellow. It
may be produced simply by the fusion of litharge and common salt;
the alkali being volatilized, and driven off, if the fire be sufficiently
intense. T.

factories of soda have afforded a very considerable quantity, which is substituted instead of the fine Naples yellow.

4. The acetous acid corrodes lead; and affords a white oxide known by the name of white lead.

To prepare this colour, the lead is melted, and cast into plates about half a line in thickness, four or five inches wide, and two feet long. These are rolled up in a spiral form, in such a manner that the revolutions remain at the distance of half an inch from each other. They are then placed in pots, upon three points, which project from the inside at about one third of the height. Malt vinegar is poured into these pots to the height of the bottom of the lead, and they are buried in dung beneath sheds. A great number of these are disposed beside each other, and several strata are formed. Care is taken to cover each pot with a plate of lead and boards. At the expiration of a month or six weeks they are taken out, and the white lead is separated. This white calx is then ground in mills, and afterwards put into a vat, from which it is taken out to dry. The drying is performed in the shade, because the sun impairs the colour. For this purpose it is put into small conical earthen pots; and when sufficiently dry it is wrapped in paper, and distributed for sale.

Ceruse does not differ from white lead, excepting that a more or less considerable quantity of chalk is mixed with it.

All the oxides of lead are soluble in vinegar. The solution of the acetate of lead, duly concentrated, crystallizes in efflorescent tetrahedral prisms; and forms the salt of saturn, or sugar of lead.

Caustic alkalis dissolve the oxides of lead, and the metal may be precipitated by the addition of acids. When the alkaline solution is concentrated, the lead re-appears nearly in the metallic form, and the alkali is found to have acquired a faint and very peculiar taste.

The uses of lead in the arts are multifarious. It is used to make water pipes, boilers, coverings for the roofs of buildings, tea-chests, and other articles of package. It is rendered proper for these uses, either

by laminating it, or by causing it to flow out upon a bed of sand well rammed and levelled, or upon the cloth called ticking.

It is likewise used to make bullets and small shot. The bullets are cast in moulds: but the small shot is made in the following manner:—Lead is fused with a small quantity of arsenic, to render it more brittle; and when its temperature is such as to admit of a card being plunged in it without burning, it is poured into a kind of cullender, pierced at the bottom with many holes, and containing lighted charcoal; this cullender is held over water; and the lead assumes a round form as it enters this liquid.

Lead is used in the tinning of copper vessels. This is a pernicious fraud supported by custom, and tolerated by the want of vigilance in the police. It is the more dangerous from the circumstance that fats, oils, and vinegar corrode or dissolve lead, which by that means becomes mixed with the aliments.

Lead ore is likewise used to glaze pottery. For this purpose galena is pulverized, and mixed with water. The vessel intended to be glazed is dipped into this fluid, after having been exposed to a first baking. It accordingly becomes covered with the galena; which, when exposed to a violent heat, passes to the state of glass, and forms a covering of the glass of lead over the whole surface. This process is attended with the inconvenience of introducing a dangerous poison into our culinary vessels whose effects on the health of individuals cannot but be sensibly felt.

Oxided lead enters into the composition of glasses, crystals, and enamels. It possesses the advantage of facilitating the fusion, and giving the glass an unctuous feel, and a degree of softness, which renders it capable of being cut and polished.

White lead and ceruse are used by painters.* These

* Cadet de Vaux has proposed to substitute the following composition, in the place of white lead paint.

Take of skimmed milk two quarts, fresh slacked lime six ounces and a half, linseed or nut oil four ounces, common whiting three pounds; put the lime into a stone ware vessel, and pour upon it a sufficient quantity of milk to make a mixture resembling thin cream,

oxides possess the singular advantage of not being percep-
tibly altered by their mixture with oil; and form, by
their whiteness and body, a basis or receiver, which is
very suitable for a variety of colours. The workmen
who grind these colours are affected by them; and sooner
or later become subject to the painters colic, *colica pic-
torum.*

Litharge is at present used to decompose sea salt; and
the muriate of lead by fusion forms a superb yellow, very
much employed in varnish colours.

8. Ceruse is likewise much used for drying up ha-
bitual moisture of the skin, and for slight burns. It is
applied to the skin in the form of powder, and there is
no remedy more speedy.

The salt of saturn, or sugar of lead, is almost entirely
used by the calico printers.

The vinegar of saturn, or the vegeto-mineral water
of Mr. Goulard, is a very proper astringent in the con-
sequences or remains of venereal disorders: it is like-
wise used to wash burns and ulcers, and to facilitate their
cure.

This extract is likewise used to clarify liquors, and to
deprive brandies of their colour; an evil practice which
has been common for some years at Sette, though prohi-
bited under heavy penalties.—The wine merchants avail

then add the oil a little at a time, carefully stirring it to make it mix
thoroughly; the remainder of the milk is then to be added, and last
of all the whiting is to be crumbled, and spread upon the surface of
the fluid in which it gradually sinks; at this period it must be well
stirred in, and the paint is fit for use.

It is to be applied by a brush, in the usual manner, and in a few
hours will become perfectly dry.

Another coating may then be added, in the same manner as the
former, and thus the work is completed.

This paint is said to possess great solidity, and a slight elasticity,
which enables it to bear rubbing with a coarse woollen cloth, without
being in the least degree injured. It has no smell. It is not black-
ened by any vapours, and does not injure the health.

For out door work, a much greater degree of solidity is given to
the paint by increasing the proportion of lime to eight ounces and a
half; of the oil six ounces, and adding two ounces of white Burgun-
dy pitch. The pitch is to be melted by a gentle heat in the oil, and
then added to the smooth mixture of milk and lime. *Decade Philo-
sophique, No.* 29, *year* 9.—*Am. Ed.*

themselves of this composition but too often, or of li-
tharge, to render their sour wines sweet.   This fraud
was prodigiously common at Paris in the year 1750 ; and
it was proved that, in the interval of three years, thirty
thousand muids of vinegar had been thus sweetened; and
sold for wine.

The oxides of lead are likewise used to harden oils, or
to render them more drying.   In this operation the oxi-
gene of the oxide combines with the oil, and causes it to
approach nearer to the nature of resins.   There is like-
wise a solution of lead in oils, which serves as the basis
of plasters.

CHAPTER IX.

Concerning Tin.

TIN is a metal of a white colour, intermediate be-
tween that of lead and silver.   It is very flexible,
and produces a crackling noise when bended.   No other
metal possesses this property except zinc, in which it is
infinitely less marked.

This metal is very soft, and the lightest of any of the
entire metals.   The specific gravity of fused tin is 7,2914,
according to Brisson.

A cubic foot of this metal weighs about five hundred
and ten pounds.   It is very ductile under the hammer; and
its tenacity is such, that a wire one tenth of an inch in
diameter is capable of supporting forty-nine pounds eight
ounces without breaking.   Mr. De la Chenaye has crys-
tallized tin after several repeated fusions; he obtained by
this means an assemblage of prisms united together side-
ways.

Tin has been found in the metallic state in the bowels
of the earth.   Mr. Sage possesses a specimen from the
mines in Cornwall, and Mr. De Lisle likewise has one in
his collection.   This tin, so far from exhibiting any trace
of fusion, has the external appearance of molybdena: it

is easily broken; but the detached pieces may be flatten-
ed by the hammer.

Tin ore is either white or coloured.

1. The white tin ore, which has been often confound-
ed with tungsten, crystallizes in octahedrons. Its texture
is lamillated, and it frequently includes portions of red-
dish tin ore. That of Cornwall afforded Mr. Sage sixty-
four pounds of tin in the quintal.

2. The coloured tin ore does not differ from the pre-
ceding, excepting that it contains iron, and sometimes
cobalt. This ore usually has the form of irregular poly-
hedrons.

These ores afford carbonic acid by distillation when
exposed to fire in a crucible. They decrepitate, lose
somewhat of their colour, and become one-tenth less
heavy.

Bergmann found sulphureous tin among the minerals
he received from Siberia. He affirms that this was of a
golden colour externally, resembling aurum musivum;
and internally it presented a mass of radiated, white, bril-
liant, brittle crystals, which assumed changeable colours
on exposure to the air.

To assay a tin ore, nothing more is necessary than to
fuse it in the midst of the coals. Calcination in the open
fire dissipates much of the metal, according to the obser-
vation of Cramer.

In the working of tin ores, the mineral must be sorted
very exactly; after which it is to be pulverized, and wash-
ed upon tables covered with cloth. By agitation with a
wisp or broom, the gangue is suspended or carried away
by the water, and the tin ore remains alone.

The furnace made use of in Saxony for the fusion of
tin ore, is a variety of the blast furnace, on the hearth of
which is a groove to receive the melted metal, and con-
vey it into a bason; whence it is taken to be cast in
moulds of copper or of iron.

The tin ores of Cornwall are frequently mixed with
copper, and arsenical pyrites. The quartz, which is its
gangue, is very hard; and on this account the operation
is begun by torrefaction of the ore before it is pulverized.
After the ore is washed, a separation of the magnetical

iron is effected by means of loadstones.   The ore is usu-
ally fused in the reverberatory furnace.

In Saxony, and in England, the scoriæ are three times
fused to separate the tin, after which they are pounded to
separate the last portions of metal.   As the vein of tin in
the mines of Cornwall is always mixed or accompanied
with a vein of copper, the tin must contain this latter me-
tal, however great the precautions which may be attended
to in the working.

We are acquainted with three kinds of tin in com-
merce.

1. Pure tin, such as that of Malacca, of Banca, and
the soft tin of England.   The tin of Malacca is cast into
moulds, which give it the form of a quadrangular trun-
cated pyramid, with a small rim at its base.   It is called,
in France, *Etain en Chapeau*, or *en Ecritoire*.   Each
ingot weighs one pound.—The tin of Banca is in the form
of oblong ingots, weighing from forty to forty-five pounds
each.

2. The English tin, in large pigs, is cast into sticks of
ten or twelve lines in diameter, and a foot and a half long.

3. The tin of the pewterers is alloyed with various
metals.   The law in France permits them to add copper
and bismuth ; and they of their own authority add zinc,
lead, and antimony.

Every kind of tin enters into fusion with considerable
facility, for it is the most fusible of the metals.   If it be
kept in fusion for a short time, exposed to the action of
the air, the surface becomes wrinkled, and covered with
a grey pellicle.   If this first covering be taken off, the
tin appears with all its brilliancy ; but soon becomes dull,
and is oxided again.   Tin gains one tenth of its weight,
by this calcination.   When the oxide is white, it is then
called Putty.   It is this oxide of tin which the makers of
pewter spoons, who usually travel over the country, call
the Dross of Tin.   They are very careful to scum the
metal as often as possible, to clear it of the dross ; and
by this means they avoid giving the peasant any more of
his old pewter than that which they cannot contrive to
take away from him.   They are very well acquainted with
the art of fusing this pretended dross into good tin, by
heating it in contact with charcoal.

The putty of tin is used to polish hard bodies ; and to render glass opaque, which converts it into enamel. Tin takes fire by a violent heat, according to Geoffroy ; and a white oxide sublimes, while part of the tin is converted into a glass of a hyacinthine colour.

If tin be kept in fusion in a lined crucible, and the surface be covered with a quantity of charcoal to prevent its calcination, the metal becomes whiter, more sonorous and harder, provided the fire be kept up for eight or ten hours.

Tin, and several other metals, may acquire a brilliancy they do not usually possess, by pouring them out at the moment before they would congeal in the crucible. This treatment secures them from the oxidation they suffer in cooling, when they are poured out too hot ; and by this method, which is very simple, I have procured to tin and lead a degree of brilliancy which they would hardly be thought capable of exhibiting.

Tin, distilled in close vessels, affords a white sublimate in the neck of the retort, which Margraff took for arsenic ; but Messrs. Bayen and Charlard have proved that it was not that substance.

The action of acids upon tin varies according to the degree of purity of the metal.

The sulphuric acid of commerce dissolves tin, by the assistance of heat ; but part of the acid is decomposed, and flies off in the form of very penetrating sulphureous acid. Water alone precipitates this oxided metal. Mr. Monnet has obtained crystals by calcination, which resemble fine needles, interlaced among each other. The sulphuric acid dissolves the oxide of tin much better.

The nitric acid devours tin. The decomposition of this solvent is so speedy, that the metal is seen to be precipitated, almost instantly, in a white oxide. If this acid be loaded with all the tin it is capable of calcining, and the oxide be washed with a considerable quantity of distilled water, a salt may be obtained by evaporation, which detonates alone in a crucible well heated, and which burns with a white and thick flame, like that of phosphorus. The nitrate of tin, distilled in a retort, swells up, boils, and fills the receiver with a white and thick vapour, which has the smell of nitric acid.

Mr. Baumé even pretends that the nitric acid does not dissolve tin; but Kunckel, and the famous Rouelle, have maintained the contrary. Messrs. Bayen and Charlard dissolved five grains in two gross of pure nitric acid, diluted with four gross of distilled water.*

The muriatic acid dissolves tin, whether cold or heated. During the effervescence, a very fetid gas is disengaged. The solution is yellowish, and affords needle-form crystals by evaporation, which attracts the humidity of the air. Mr. Baumé prepared this salt in the large way for the calico printers. Out of twelve pounds of tin, dissolved in forty-eight pounds of acid, he had a residue of two ounces six gross of a grey and soluble powder, which Margraff had taken for arsenic. Mr. Baumé has observed that the crystals of the muriate of tin differ according to the state of the acid. He obtained crystals, similar to those of the sulphate of soda, in needles, or in scales like those of the acid of borax. Mr. Monnet asserts that he obtained, by the distillation of a muriate of tin, a fat matter, a true butter of tin, and a liquor resembling that of Libavius.

The oxigenated muriatic acid dissolves tin speedily; and the salt which it produces, possesses all the characters of the ordinary muriate, according to Mr. De Fourcroy.

That which is known by the name of the Fuming Liquor of Libavius, appears to me to be a muriate of tin, in which the acid is in the state of the oxigenated muriatic acid. To make this preparation, tin is amalgamated with one-fifth of mercury; and this amalgam in powder is mixed with an equal weight of corrosive sublimate. The whole is then introduced into a retort, a receiver

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* The nitric acid, when pure and concentrated, has no action on tin, but if water be added to the mixture, it is decomposed, and nitrous oxide, nitrous air, nitrate of ammoniac, and oxide and nitrate of tin are formed. In this case, part of the oxigene of the water and nitric acid, unite to the tin, and form a white oxide, a portion of which is dissolved by the acid, and nitrate of tin is made. Another part of the oxigene of the acid and water, joins some of the azote of the acid, generating nitrous oxide and nitrous air. The hydrogene of the water, combines with another portion of the azote of the acid, and forms ammoniac, which unites to the acid, and makes nitrate of ammoniac. This gas may be set at liberty, by putting potash or lime in the vessel in which the experiment is made.—*Am. Ed.*

adapted, and distillation proceeded upon by a gentle heat. An insipid liquor passes over first, which is followed by a sudden eruption of white vapours, which condense into a transparent liquor, that emits a considerable quantity of vapours by mere exposure to the air. The residue in the retort, for an analysis of which we are indebted to Mr. Rouelle the younger, consists of a slight lining in the neck of the retort, which contains a small quantity of the fuming liquor, some muriate of tin, muriate of mercury, and running mercury. The bottom of the vessel contains an amalgam of tin and mercury; above which lies a muriate of tin of a grey white, solid and compact, and which may be volatilized by a strong heat.

The nitro-muriatic acid dissolves tin with vehemence: a violent heat is excited; and it frequently happens that a magma is obtained resembling pitch, which becomes harder in process of time. This happens when the very concentrated acid has dissolved too much of the metal; and these inconveniences may be obviated by adding water in proportion as the solution proceeds.

The solution of tin which constitutes the composition for scarlet, is made with the common aqua-fortis, prepared with saltpetre of the first boiling. This is a kind of nitro-muriatic acid, which unfortunately varies in its properties, according to the two variable proportions of muriate of soda and nitrate of potash. For this reason, the dyers are continually making complaints, either that the aqua fortis precipitates, which happens when it contains too small a quantity of muriatic acid; or that it affords an obscure colour, which depends on an excess of the same acid. The first inconvenience is remedied by dissolving sea salt, or sal ammoniac, in the aqua-fortis; and the second by adding saltpetre.

The most accurate proportions to make a good solvent for tin, are, two parts of nitric acid, and one of muriatic acid.

Tin is likewise soluble in the vegetable acids. Mr. Schultz, in his Dissertation *De Morte in Olla*, has demonstrated the solubility of this metal in acids. Vinegar corrodes it by a gentle heat, according to the experiments of Margraff.

Most of the tin in commerce is alloyed with various metals. That of England contains copper and arsenic artificially, according to Geoffroy; and naturally, according to the Baron Dietrich, Sage, &c. The tin of the plumbers or pewterers, called Pewter, contains several metals. The ordonnance in France permits them to add a small quantity of copper and bismuth. The first metal renders it hard; and the latter restores the brightness which would else have been impaired by the copper, and renders it more sonorous. The pewterers take upon themselves to add antimony, zinc, and lead; the antimony hardens it, the zinc renders it whiter, and the lead diminishes its value. It is a desirable circumstance to possess the means of ascertaining the nature and proportions of these alloys. We are indebted for the following processes to Messrs. Bayen and Charlard.

A. When tin contains arsenic, the solution in the muriatic acid exhibits a black powder, which consists of arsenic separated from the tin. This method is capable of rendering the two thousand and forty-second part of alloy perceptible.

B. If the tin contains copper, the muriatic acid, which attacks tin with facility, precipitates the copper in the form of a grey powder, provided there be no excess of acid, and the solution be made without heat. The copper is likewise precipitated by a plate of tin immersed in the solution.

C. Bismuth is shewn by the same process as the copper.

D. To ascertain the mixture of lead, the nitric acid must be used, which corrodes the tin, and dissolves the lead.

The pewterers have two methods of assaying this metal.

1. The assay of the stone, which consists in pouring it into a hemispherical cavity made in a calcareous stone, and terminating in a channel or groove. The workman attentively observes the phenomena of its cooling; and from these circumstances, as well as from the crackling or noise which the tail of the assay affords when bended, he judges of the purity of the metal.

2. The assay by the ball consists merely in a comparison of the weight of pure tin with that of adulterated or alloyed tin, poured into the same mould.

It cannot but be immediately perceived that these methods are very imperfect.

The various metals which are prejudicial to health, are not added to the tin in a sufficiently great proportion to produce any dangerous effects. It seems that Margraff was deceived by some foreign circumstance, when he affirmed that the tin of Morlaix contains thirty-six grains of arsenic in the half ounce; for this quantity is more than sufficient to render the metal as brittle as zinc. Messrs. Bayen and Charlard found no arsenic in the tin of Banca and of Malacca. The tin of England never contains more than three-fourths of a grain of arsenic in the ounce of metal; and supposing this to be the maximum, the daily use of tin cannot be dangerous; since a plate in which arsenic existed in this proportion, lost no more than three grains per month by constant use, which amounts to the five thousand seven hundred and sixtieth part of a grain of arsenic lost daily. The experiments which these two skilful chemists have made upon animals, by mixing arsenic in larger proportions with tin, are sufficient to remove every apprehension concerning the use of this metal.

The lead alone may be productive of dangerous consequences, because the pewterers add it in a very considerable proportion.

The combination of tin with sulphur forms aurum musivum, or mosaic gold. The process for making it which has best succeeded in my hands, is that described by the Marquis de Bullion. It consists in forming an amalgam of eight ounces of tin and eight ounces of mercury. For this purpose, a copper mortar is heated, and mercury poured into it; and when it has acquired a certain degree of heat, the melted tin is poured in, and the mixture agitated and triturated till cold. Six ounces of sulphur, and four ounces of sal ammoniac, are then mixed; and the whole put into a matrass, which is to be placed on a sand bath, and heated to such a degree as to cause a faint ignition in the bottom of the matrass. The fire must be kept up for three hours. The aurum musivum

thus obtained is usually beautiful : but if, instead of placing the matrass on the sand, it be immediately exposed upon the coals, and strongly and suddenly heated, the mixture will take fire, and a sublimate will be formed in the neck of the vessel, which consists of the most beautiful aurum musivum. I have obtained it by this process of a dazzling colour in large hexagonal scales.

The mercury and the sal ammoniac are not in strict-ness necessary to the production of aurum musivum. Eight ounces of tin dissolved in the muriatic acid, preci-pitated by the carbonate of soda, and mixed with four ounces of sulphur, produced the Marquis of Bullion a fire aurum musivum : but this is not capable of increas-ing the effects of the electrical machine, which proves that the composition owes its virtue in that respect to the mercury it contains in the proportion of six to one, when prepared in the former process. This preparation is used to give a beautiful colour to bronze, and to increase the effects of the electrical machine by rubbing the cushions.

The Baron Kienmayer has described the following amalgam, composed of two parts of mercury, one of zinc, and one of tin :—The zinc and the tin are to be fused, and mixed together with the mercury ; and the mixture agitated in a wooden box, internally rubbed with chalk. The mass is then to be reduced to a fine powder; and employed in that state, or mixed with grease. The effect of this amalgam is surprising ; for by this means the power of electrical machines is inconceivably augmented.

The amalgam of tin is capable of crystallization. Mr. Sage's process consists in pouring two ounces of melted tin into a pound of mercury. After having introduced this mixture into a retort, he urged it by a violent fire for five hours on the sand bath. No mercury was disen-gaged ; but the tin was found in a crystallized state above the mercury which had not entered into combination. The lower part of this amalgam is composed of grey brilliant crystals in square plates, thin towards their edges, having polygonal cavities between each. Every ounce of tin retains in its crystallization three ounces of mer-cury.

The amalgam of tin is used to silver looking-glasses. For this purpose, a leaf of tin is spread out upon a table of the size of the glass, mercury is poured upon it, and spread about with a brush. This being done, a larger quantity of mercury is poured upon the tin, so as to form a covering of more than one line in thickness. The glass is slided upon this covering, by presenting one of its edges; taking care at the same time that its surface shall be beneath the level of the mercury, in order that the impurities which might hinder a perfect contact may be driven before it. The plate of glass is then loaded with weights equally distributed over its whole surface; by which means all the excess of mercury is pressed out, and flows away through channels made in the edges of the table. The air being driven out from between the amalgam of tin and the glass by this strong compression, serves greatly to render the amalgam adherent. Several days are required to elapse before it be sufficiently dry to admit of removing the glass.

Tin alloyed with copper forms bronze, or bell-metal. Seven parts of bismuth, five of lead, and three of tin, form an alloy which liquefies in boiling water.

CHAPTER X.

Concerning Iron.

IRON is the most generally diffused metal in nature. Almost every mineral substance of this globe is colour- ed with it; and its various alterations produce that truly astonishing variety of colours which are comprehended between the blue and the deepest red. This metal like- wise exists in the vegetable kingdom, where it consti- tutes an almost inseparable principle. It even appears to be one of the products of organization, or vegetation; for it is found in vegetables which are supported merely

by air or water. It is indeed contrary to sound philosophy to suppose that all the iron with which earths are impregnated, must arise from the wearing of plough-shares: for, not to mention that the plough has not passed every where, we see iron daily formed in vegetables. There is no reason to fear that the metal should on this account become too abundant; because it is continually destroyed by passing to the state of oxide.

If on the other hand, we cast our attention towards the infinite number of uses to which this metal is applied in society, we shall perceive that it is perhaps the most essential to be known, because it is the most diffused, the most useful, and the most employed.

This metal is of a white livid colour, inclining to grey, obedient to the magnet, and gives fire with quartz; which last circumstance is attributed to the fusion and rapid combustion of particles of the metal detached by the stroke. It is the lightest of all metals except tin. One cubic foot of forged iron weighs five hundred and forty-five pounds. The specific gravity of fused iron is 7,2070. —See Brisson.

Iron is very hard, susceptible of a fine polish, and very difficult of fusion. It may be drawn into very fine wire, of which the strings of the harpsichord are made. It becomes hard by hammering, without heat; but when assisted by heat, it may be hammered into every imaginable form.

Iron is universally dispersed; but, by common consent, those places, or matrices, in which the iron is sufficiently abundant to be wrought with profit, are called Iron Mines, or Ores.

Iron is found native, without mixture, in several places. We shall not here mention those ridiculous assertions, which have no other merit than that of having been authorized by the suffrages of certain celebrated men.— " ALBERTUS MAGNUS decidisse cœlum, imbre, massam ferri centum librarum. *Petermannus*, magnâ tempestate, cum projectu multorum lapidum, cœlo molem ferri decidisse, quæ in longitudine sexdecim, in latitudine quindecim in crassitie duos, pedes habuerit :" that is, of the weight of forty-eight thousand pounds, and containing

four hundred and eighty cubic feet.—Becher supplem. in
Phys. Subter. cap. iii. p. 599.*

We are indebted to Lehman for a description of a piece
of native iron possessed by Margraff, which came from
Eibenstock in Saxony. The grain was distinguishable
on both sides.

Henckel possessed a small piece incrusted with a yel-
low earth; and the cabinet of the Royal School of mines
possesses one which is covered with spathose iron ore. A-
danson and Wallerius affirm that it is found in Senegal;
and Rouelle received a piece from thence which was very
malleable. Simon Pallas speaks of a mass of native iron
found near the great river Jenesei in Siberia. This iron
is a very spongy, very pure, perfectly flexible, and pro-
per to be formed into instruments by a moderate fire. It
is naturally incrusted with a kind of varnish which pre-
serves it from rust.

Mr. Macquart doubts the legitimacy of the native iron,
described by Pallas: he thinks that it may be considered
as fused iron. Mr. De Morveau does not believe in the
existence of native iron.

Though some doubts may be raised concerning the le-
gitimacy of these pieces, and there may be reasons to
consider some of them as consequences of the action of

* A number of stones, composed of iron, silex, magnesia, and nick-
el, have fallen upon the earth in different parts of the world.
Their origin is unknown.

They have been considered as productions thrown on the earth,
by volcanos or hurricanes; as mineral substances, fused by light-
ning; as concretions in the atmosphere; and as masses, foreign to
our planet.

One of these stones fell at Creon, in the parish of Juliac, on the
24th of July, 1790, about nine in the evening.

It appeared as a very bright fire ball, the light of which was as
pure as that of the sun; it had the size of a common air balloon, and
was long enough visible to throw the inhabitants into the greatest
consternation, after which it burst, and disappeared. A few days af-
ter this, some peasants brought stones, which they said were the re-
sult of the fall of the meteor.

The opinion, says Vauquelin, which makes them come from the
moon, however extraordinary it may appear, is perhaps the least
improbable, and if it be true, that no direct proofs can be given of
this opinion, it is equally certain, that no well founded reasoning can
be opposed to it.—*Am. Ed.*

The following Table will shew in what part of the World, the Stones have fallen.

Substances.	Places where they fell.	Period of their Fall.	Testimonies.
Shower of stones	At Rome	Under Tullus Hostilius	Livy
Shower of stones	At Rome	Consuls C. Martius & M. Torquatus	J. Obsequens
Shower of iron	In Lucania	Year before the defeat of Crassus	Pliny
Shower of mercury	In Italy		Dion
A very large stone	Near the river Negros, Thrace	Second year of the 78 Olympiad	Pliny
Three large stones	In Thrace	Year before J. C. 452	Ch. of count Marcellin.
Shower of fire	At Quesnoy	Jan. 4th, 1717	Geoffroy le Cadet
Stone of 72 lbs.	Near Larissa, Macedonia	Jan. 1706	Paul Lucas
About 1200 stones—one of 120 lb. Another of 60 pounds	Near Padua in Italy	In 1510	Cardan, Varcit
A stone of 59 pounds	On Mount Vasier, Provence	Nov. 27th, 1627	Gassendi
Shower of sand for 15 hours	In the Atlantic	April 6th, 1719	Père la Feuillée
Shower of sulphur	Sodom and Gomorra		Moses
Sulphureous rain	In the dutchy of Mansfield	In 1658	Spangenberg
The same	Copenhagen	In 1646	Olaus Wurmius
Shower of sulphur	Brunswick	Oct. 1721	Siegesber
Ditto of a viscid unknown matter	Ireland	In 1695	Muschenbroek
Two large stones weighing 20 lbs.	Liponas in Brese	Sept. 1753	Delalande
A stony mass	Niort, Normandy	In 1750	Delalande
A stone of 76 lbs.	At Luce in Le Maine	Sept. 13th, 1768	Bachelay
A stone	At Aire in Artois	In 1768	Gurson de Boyaval
A stone	In De Cotentin	In 1768	Morand
Extensive shower of stones	Environs of Augen	July 24th, 1790	St. Amand, Baudin, &c.
About 12 stones	Sienna, Tuscany	July 1794	Earl of Bristol
A large stone of 56 lbs.	Wold Cottage, Yorkshire	D. c. 13th, 1795	Capt. Topham
A stone of about 20 lbs.	Salé, department of the Rhone	March 17th, 1798	Lelievre and De Drée
A stone of 10 lbs.	In Portugal	Feb. 19th, 1796	Southey
Shower of stones	Benares, East Indies	Dec. 19th, 1798	J. Lloyd Williams, esq.
Shower of stones	At Plann, near Tabor, Bohemia	July 3d, 1753	B. de Born
Mass of iron 70 cubic feet	America	April 5th, 1800	Philosophical Magazine
Mass of ditto, 14 quintals	Abakank, Siberia	Very old	Pallas, Chladni, &c.
Shower of stones	Barboutan, near Roquefort	July 1789	Darcet jun. Lomet, &c.
Large stone, 260 lbs.	Ensisheim, Upper Rhine	Nov. 7th, 1492	Butenschoen
Two stones, 200 and 300 lbs.	Near Verona	In 1762	Acad. de Bourd.
A stone of 20 lbs.	Sales, near Ville Franche	March 12th, 1798	Du Drée
Several ditto from 10 to 17 lbs.	Near L'Aigle, Normandy	April 26th, 1803	Fourcroy.——*Am. Ed.*

fire, we cannot however refuse to admit of the existence
of native iron, after the depositions, facts, and attestations
which present themselves on all sides in support of this
truth.

Iron, slowly cooled, crystallizes in octahedrons almost
always implanted one in the other. We are indebted to
Mr. Grignon for this observation. I am in possession of
a piece of iron entirely covered with small tetrahedral,
flat, and truncated pyramids. Some of the pyramids have
a base of one line in breadth. It comes from the fron-
tiers of the Comté de Foix. This iron is very seldom
found unaltered by foreign admixtures; but I think we
may consider all the iron ores which are attracted by the
magnet, as containing the native metal, dispersed in some
gangue: and we shall attend to these species before we
treat of the oxides and martial salts.

ARTICLE I.

Concerning Iron Ores which are attracted by the Mag-net.

1. The octahedral iron ore.—This ore has the form of
octahedrons, isolated, and dispersed in a gangue of schis-
tus, or calcareous stone. The crystals are grey, very re-
gular in their form, and strongly bedded in the stone.
Their size is from half a line to six or seven in diameter.
Corsica and Sweden afford this kind.

Mr. Sage observes that octahedral crystals of iron are
sometimes found in the finest white marble of Carara.
The black ferruginous sand which accompanies the hya-
cinths in the brook of Expailly, is an octahedral iron ore,
obedient to the magnet.

2. Iron ore in small plates or scales.—The small plates
or scales which are attracted by the magnet, and are found
in most rivers which contain gold, are an iron ore, nearly
in the metallic state. This sand forms the residue which
is left after the precious metal has been taken up by amal-
gamation. It is mixed with fragments of quartz, garnets,
&c. I found a large quantity in the sand of the river of
Ceze: it was also sent me from the neighbourhood of

Nantz.   I have received some likewise from Spain ; and
this sand has afforded me certain phenomena which ap-
pear to entitle it to a particular rank among the metals.
Acids dissolve it by the assistance of heat ; and always
without effervescence, or the disengagement of gas.   It
communicates the same colour to the nitro-muriatic acid
as platina does.   It is indecomposable by heat, either in the
open fire, or in open vessels.   I have endeavoured to re-
duce it by all the known fluxes, but in vain.   It precipi-
tates in the flux, mixes with it, and recovers its form and
magnetic virtue by pulverizing the mass.   It possesses
several characters of the siderite, or phosphate of iron.

3. Iron dispersed in stones renders them obedient to
the magnet.   The ophites, the serpentines, the micas, the
pot-stones, and several marbles, are in this situation.   Iron
disseminated in a gangue of quartz, or very hard jasper,
forms emery, which on account of its hardness is used to
grind and polish glass.   It comes to us from Jersey and
Guernsey, where it is plentifully found.

The magnet itself is nothing else but the iron we speak
of, modified in such a manner as to afford a passage to
the magnetic fluid, and to exhibit the known phenomena.
The magnet is sometimes found in a regular form.   Mr.
Sage affirms that he possesses a small piece of magnet
from St. Domingo, on which octahedrons are distinguish-
able.   We have likewise read, in the General History of
Voyages, that at twenty leagues from Solikamskai in Si-
beria magnets are found of a cubical form and greenish
colour, of a lively brilliant appearance, which are redu-
cible into glittering scales by pulverizing.

The magnet varies in its quantity of metal.   Those of
Sweden and Siberia are very rich in iron ; but the mag-
netic force is not in proportion to the iron they contain.

There is reason to think that the magnetic agent is a
modification of the electric power.   1. Iron which re-
mains a long time in an elevated position becomes mag-
netic.   2. Instruments of iron struck with lightning are
usually magnetized.   3. Two pieces of iron may be
magnetized by rubbing them against each other in the
same direction.   4. Black iron ores are found in Sweden
which are attracted by the magnet, and whose metallic
particles are sometimes so weakly connected together that

they are reducible into powder. We have several species
of these ores in Languedoc.

This species is in general very rich, and affords near
eighty pounds of iron per quintal.

5. Iron appears to exist in the metallic state in some
other species, such as the specular iron ore. But the me-
tallic state is less evident and characteristic, the metallic
qualities being more changed ; and these ores are less at-
tracted by the magnet.

These iron ores frequently exhibit metallic plates of a
brilliancy equal to that of steel, and unalterable in the air.
The ore of Mont d'Or, that of Framont in the principal-
ity of Salm, and those of the mountains of Vosges, have
afforded us very curious specimens. These plates are
sometimes hexagonal, formed by two hexahedral pyra-
mids truncated near their base.

The specular iron ore of Framont afforded Mr. Sage
fifty-two pounds of iron in the quintal : the iron is very
ductile, and acquires much fibre.

The celebrated iron ore of the island of Elbe is of this
kind, but it has not the plated form. Its crystals are len-
ticular, with brilliant facets, which are dodecahedrons
with triangular planes. These beautiful groupes of cry-
stals are sometimes shaded with the most lively colours.
White clay, rock crystal, cupreous pyrites, &c. are found
among them.

The Lucquese work this ore in the Catalan method,
by stratifying charcoal and the ore, one layer over the
other. The fire is kept up by good bellows ; and when
all the coal is consumed, the iron is found collected toge-
ther in a mass, which is carried to the hammer.

The eisenman is a scaly specular ore. When it is rub-
bed, brilliant particles are detached from it ; which has
caused the miners of Dauphiny to give it the name of
Luisard.

The eisenman is an iron ore of a brilliant red colour,
which contains plumbago and iron.*

* Iron mines are numerous in the United States. The toughness
of some of the cast iron made in Virginia, says Mr. Jefferson, is
very remarkable. Pots and other utensils of this iron, cast thinner
than usual, may be safely thrown into and out of waggons, in which
they are transported.

ARTICLE II.

Concerning Sulphureous Iron Ores, or the Sulphures of Iron.

The union or combination of iron and sulphur forms the sulphureous iron ore, martial pyrites, sulphure of iron, &c.   These sulphures are very abundant, and are evidently formed by the decomposition of vegetables.   I have several times found pieces of wood buried in the earth perfectly incrusted with pyrites.   The effect of subterraneous fires is owing only to the mixture of these sulphures with the remains of vegetables.   Those species of coal which effloresce in the air, owe their decomposition only to the pyrites with which they are penetrated.   It is likewise to the decomposition of the pyrites that we must refer the heat of most mineral waters.   The sulphure of iron sometimes crystallizes in cubes, and often in octahedrons.   The union of a number of octahedral pyramids with their points towards a common centre, forms the globular pyrites.

When the sulphur is dissipated, it sometimes happens that the pyrites loses neither its form nor its weight. It then becomes brown, is attracted by the magnet, and is called the Brown or Hepatic Iron Ore.—See De Lisle.

But the decomposition of pyrites most commonly produces the sulphuric acid, which seizes the iron, dissolves it, and forms an efflorescence on the surface.   Advantage has even been taken of this property of the pyrites to establish manufactories of sulphate of iron, or copperas. The two valuable establishments which have been made of this kind, in the vicinity of Alais, work certain strata of a hard ponderous pyrites.   These are formed into heaps upon areas, where the ground is slightly inclined.   The efflorescence is accelerated by watering the pyrites, grossly broken, with water.   This fluid dissolves all the salt

Salt pans made of it, and no longer wanted for the purpose of making salt, cannot be broken up, in order to be melted again, unless previously drilled in many parts.—*Am. Ed.*

which is formed, and carries it into reservoirs, where the
solution suffers all the foreign matters it may contain to
subside.   It is left at rest in these reservoirs, in which
the sun produces a slight concentration of the fluid ; and
the concluding evaporation is made in leaden cauldrons
with the addition of old iron, to saturate the acid with as
much of that metal as possible.   The crystallization is
performed in basons, in which pieces of wood are dispos-
ed to assist the formation of crystals.   These two manu-
factories in Languedoc are capable in their present state,
of furnishing upwards of forty thousand quintals of cop-
peras, if the demand required it.

In order to facilitate the vitriolization, it is necessary
to give access to the air, because the concurrence of this
element is necessary to form the sulphuric acid.

The sulphate of iron crystallizes in rhomboids.*

It effloresces in the air, and gradually loses its fine
green colour by the dissipation of its water of crystalli-
zation.

If the sulphate of iron be exposed to heat, it lique-
fies, boils, becomes thick, and is reduced into powder.
This powder, mixed with pulverized nut galls, forms a
dry ink, which several persons sell as a secret, and

* The green vitriol or copperas of the shops contains two salts,
known by the names of the sulphate and oxy-sulphate of iron.
The oxy-sulphate may be formed by exposing a solution of sul-
phate of iron, to the open air, or by pouring into it nitric acid, and
applying heat   The salt is of a red colour, and will not crystal-
lize.   It deliquesces when exposed to the action of atmospheric
air, and is soluble in water and alkohol.

It may be separated from green vitriol by alkohol.   When the
gallic acid is added to a solution of the oxy-sulphate of iron, it strikes
a deep black colour, but produces no effect on a solution of the sul-
phate of iron.

Both these salts absorb nitrous gas.

Many bodies have the property of depriving the oxy-sulphate of
iron, of its excess of oxigen, and of converting it into sulphate of
iron.

When the solution of the oxy-sulphate is mixed with iron filings,
and kept in a covered vessel, part of the iron is dissolved by abstract-
ing the second dose of oxigen from the oxide, and the whole is con-
verted into sulphate.   Tin produces the same effect.   Sulphurated
hydrogen gas brings on the change instantaneously, when made to
pass through a solution of oxy-sulphate of iron.—*Am. Ed.*

which requires only the addition of water to render it fit
for use.

The same powder, urged by a stronger heat, suffers
its acid to escape; after which there remains only a
martial earth, or metallic oxide, known by the name of
Colcothar.

I attribute the formation of all the yellow or red earths,
commonly called ochres, to a similar decomposition of
the pyrites. The heat produced by the decomposition
of the pyrites has determined the respective colours of
these earths; and they may be caused to pass artificially
through these various shades, by treating them with va-
rious degrees of fire. I have discovered, in the diocese
of Uzes, banks of ochre of such uncommon fineness,
and so very pure, that calcination converts it into a brown
red, superior to every thing before known in trade.
The manufactory which has been established under my
care, has acquired all the celebrity which the superiority
of its products could not but necessarily afford it. My
experiments on these ochres, and the advantages
which they may afford to the arts, may be seen in the
work which I have published on this subject, printed for
Didot the elder, at Paris.

I likewise found at Mas-Dieu, near Alais, a stratum of
red ochre of so beautiful a colour, that it could scarcely
be imitated.

ARTICLE III.

Concerning the Spathose Iron Ores, or Carbonates of Iron.

The carbonic acid is sometimes combined with iron
in ores; and the resemblance between this iron and
spar, has procured it the name of the Spathose Iron
Ore.

The formation of this ore appears to be owing to the
mutual decomposition of the carbonates of lime, and the
sulphates of iron. A solution of copperas, in which
calcareous spar was suffered to remain, produced this
ore, according to the experiments of Mr. Sage.

Bergmann obtained from the ores of this kind, which he analyzed, thirty-eight ounces of the oxide of iron, twenty-four ounces of the oxide of manganese, and fifty ounces of calcareous earth. It appears therefore that this ore contains two metals united by a calcareous ce-ment, which crystallizes always in its own form, as we find in the lapis calaminaris, the calcareous grit, &c.

The spathose iron ores are wrought at Cascastel, in the diocese of Narbonne, at Bendorf on the banks of the Rhine, at Eisenartz in Styria, &c.

ARTICLE IV.

Concerning the Bog Ores of Iron, or Argillaceous Iron Ores.

These ores consist merely of a martial oxide, in a state of greater or less purity, mixed with earthy sub-stances of the nature of clays.

They appear to have been deposited by water ; and are usually disposed in strata, which are frequently marked out, and as it were separated, into small prisms, whose formation arises simply from the shrinking of the clay.

1. The eagle-stone, or ætites, ought to be ranked among the bog ores of iron. They are geodes of a round or oval form, having a hard external covering, while the cavity includes a detached nodule ; and the noise produced by shaking one of these stones, arises from the nodule being at liberty to move within the stone.

The name of eagle-stone has arisen from a notion, formerly entertained, that eagles placed it in their nests to facilitate the laying of their eggs; and wonderful powers of rendering labours safe and easy, were attributed to it in the times of superstition.

2. We are acquainted with an iron ore in round pieces, resembling bullets, of several lines in diameter, which ought to be considered as a variety of the preceding. An ore of this kind was begun to be wrought at Fontanez,

near Sommieres; and we find a considerable quantity of these metallic globules among our red earths in the neighbourhood of Montpellier.

3. The purest oxide of iron, worn and carried along by waters, and afterwards, deposited, forms strata of various appearances and colours. These are called hæmatites.

The colours arise from the various degrees of alteration in the oxide. They vary from yellow to the deepest red. The red hæmatites is used in the arts to burnish gold or silver. It is cut into long pieces, which when polished are known by the name of burnishers. This blood-stone is sometimes soft enough to be used instead of a crayon for drawing.

Its figure is likewise subject to prodigious variation. It often appears as if composed of small prisms applied one against the other, in which case it is called the fibrous hæmatites. In other specimens it is tuberculated. It is very frequently found in compact irregular masses, such as those of the ores of the county of Foix. This must naturally exhibit the same variety of forms as the calcareous stalactites, because its mode of formation is nearly the same.

ARTICLE V.

Concerning native Prussian blue, or the Prussiate of Iron.

Beccer speaks of a blue earth found at Turinge. Henckel informs us that a blue martial earth is found at Schneeburg and at Eibenstock. Cronstedt has described a native Prussian blue: Mr. Sage found it in the turf of Picardy. It is likewise found in Scotland, in Siberia, &c. and I possess a sulphure of iron in a state of decomposition, which exhibits a true prussiate of iron upon one of its surfaces.*

* Native Prussian blue is found in New Jersey and in Maryland.— *Am. Ed.*

ARTICLE VI.

Concerning Plumbago, or the Carbure of Iron.

The name of Plumbago is at present confined to that shining substance of a blackish blue colour, which is used to make the pencils called black-lead pencils. It has a greasy feel, exhibits a tuberculated fracture, soils the hands, and leaves a black trace upon paper.

Plumbago is found in many places; that of commerce is brought to us from Germany. We receive it likewise from Spain, from America, and from England. It is also found in France. This mineral is almost always disposed in separate masses in the bowels of the earth; and it is probably on account of this form, that the ancients denoted it by the words Glebæ Plumbariæ.

The plumbago of England differs from the other specimens in its texture, which is much finer, and of a greater degree of brilliancy. The English do not take a larger quantity out of the mine than the market demands, in which they are careful to keep up the price.

The most plentiful mine is in the county of Cumberland.

The plumbago of Spain is always accompanied with pyrites, which effloresce on the surface of the pieces; either in small crystals, similar to those of the sulphate of iron; or in a kind of silky vegetation, analogous to that of plume alum. It is dug up in the neighbourhood of the town of Ronda, at the distance of four leagues from the Mediterranean sea. It is the worst kind which comes to market, and is used only to give a shining black colour to iron utensils.

The American plumbago, which Mr. Woulfe procured for Mr. Pelletier, breaks easily, and exhibits small quartzose grains in its internal part, as well as slight traces of a whitish clay. It is found in separate masses; and its texture appears to consist of the union of an infinity of small scaly parts, which at first sight might cause it to be taken for molybdena.*

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* Black lead is found in Bucks county, Pennsylvania, and about the grand Monadnock, in the township of Jaffrey, New-Hampshire,* and in Winterham, in the county of Amelia, in Virginia.—*Am. Ed.*
   * Belknap, vol. iii, p. 195.

France likewise possesses plumbago, and the chevalier Lamanon observed it in Upper Provence. The mine is situated near Col. de Bleoux. The black lead is found between two strata of clay, not more than a few lines in thickness. It forms a stratum of four inches thick ; or rather the stratum consists of separate masses, which are sometimes several feet in length. It is accompanied by a vein of pyrites. The inhabitants of Bleoux sell this product at Marseilles at about fifteen livres per quintal. Mr. De la Peyrouse found plumbago with tourmalines in the county of Foix, and Mr. Darcet brought it from the Pyrenean Mountains.

Plumbago is indestructible by heat without the presence of air. Mr. Pelletier exposed it to distillation, in the pneumato-chemical apparatus, by a violent fire during six hours, without the plumbago having lost weight, or suffered any other change. He exposed two hundred grains in a well-closed porcelain crucible to the fire of the manufactory at Seves, and it lost only ten grains. But when it is calcined with the concurrence of air, it then burns, and leaves but a small quantity of residue. Messrs. Quist, Gahn, and Hielm observed that one hundred grains, treated under a muffle in a shallow vessel, left only ten grains of oxide of iron. Mr. Fabroni dissipated the whole of a portion of plumbago exposed under the muffle. This calcination is a slow combustion, which is facilitated by causing the matter to present a large surface, and agitating it from time to time.

If one part of plumbago, and two of very caustic dry alkali, be heated in a retort with the pneumato-chemical apparatus, the alkali becomes effervescent, hydrogenous gas is obtained, and the plumbago disappears. This beautiful experiment proves that the small quantity of water contained in the salt is decomposed ; and that its oxigene, by combining with the carbone of the plumbago, forms the carbonic acid. The experiment published by Scheele has been repeated and confirmed by Mr. Pelletier.

The sulphuric acid does not act upon plumbago, according to Scheele. Mr. Pelletier has observed that one hundred grains of plumbago, and four ounces of oil of vitriol, being digested in the cold for several months, the acid acquired a green colour, and the property of con-

gealing by a very slight degree of cold. The sulphuric acid distilled from plumbago, passes to the state of the sulphureous acid ; at the same time that carbonic acid is obtained, and an oxide of iron is left in the retort.

The nitric acid has no action upon plumbago unless it be impure. Eight ounces of nitric acid, distilled from half a gross of purified plumbago, neither altered its shining appearance, nor deprived it of its unctuous feel.

The muriatic acid dissolves the iron and the clay which contaminate native plumbago. Messrs. Berthollet and Scheele availed themselves of this method to purify it. The liquor being decanted after digestion upon the plumbago, the residue is then washed, and submitted to distillation to separate the sulphur. The muriatic acid alone has no action upon plumbago, but the oxigenated muriatic acid dissolves it ; the result being a true combustion effected by the oxigene of the acid, and the carbone of the plumbago.

If ten parts of the nitrate of potash be fused in a crucible, and one part of plumbago be thrown thereon by a little at a time, the salt will deflagrate, and the plumbago will be destroyed. The matter which remains in the crucible consists of very effervescent alkali, and a small portion of martial ochre.

If plumbago be distilled with muriate of ammoniac, the muriate sublimes, coloured by a muriate of iron.

All these facts prove that plumbago is a peculiar combustible substance, a true charcoal combined with a martial basis. Plumbago is more common than is imagined. The brilliant charcoal of certain vegetable substances, more especially when formed by distillation in close vessels, possesses all the characters of plumbago. The charcoal of animal substances possesses characters still more peculiarly resembling it. Like it they are difficult to incinerate, they leave the same impression on the hands and upon paper ; they likewise contain iron, and become converted into carbonic acid by combustion. When animal substances are distilled by a strong fire, a very fine powder sublimes, which attaches itself to the inner part of the neck of the retort. This substance may be made into excellent black lead-pencils, as I myself have proved.

Carbone may be formed in the earth by the decompo-
sition of wood together with pyrites; but the origin of
plumbago appears to me to be principally owing to the
ligneous, and truly indecomposable, part of the wood,
which resists the destructive action of water in its decom-
position of vegetable substances. This ligneous sub-
stance disengaged from the other principles, must form
peculiar depositions and strata; and Mr. Fabroni has as-
sured me that the formation of plumbago in water is a
common phenomenon, of which he had several times
been a witness. This chemist, by his letter of the thir-
tieth of January 1787, informs me that, in the dominions
of the king of Naples, there are wells dug expressly for
the purpose of collecting an acidulous water, at the bot-
tom of which wells a quantity of plumbago is collected
every six months.

He supposes that the black mud which is found be-
neath the pavement of Paris is plumbago formed in the
humid way.

There are likewise districts in Tuscany where plum-
bago is formed in the humid way.

This substance is of considerable use in the arts. It
has been at all times applied to the purpose of making
pencils, the most esteemed of which are those which come
from England. They are made at Keswick in the coun-
ty of Cumberland. The piece of plumbago is sawed
into very thin plates. The edge of one of these plates
is fitted into a groove struck in a wooden cylinder; and
the thin plate of plumbago is then cut off in such a man-
ner that the cavity of the small cylinder remains perfectly
filled.

The dust of plumbago is used to lubricate certain in-
struments; and it is likewise made into pencils of an in-
ferior quality, by kneading it up with mucilage, or by
fusing it with sulphur. The fraud may easily be disco-
vered by the assistance of fire, which burns the sulphur;
or by means of water, which dissolves the mucilage.

Plumbago is likewise used to defend iron from rust.
The hearths and plates of chimneys, and other similar
utensils, which appear very bright, owe their colour to
plumbago. Homberg has communicated a process, in
the year 1699, in which plumbago is applied to this use.

Eight pounds of hogs-lard are melted with a small quan-
tity of water, with the addition of four ounces of cam-
phor. When this last is fused, the mixture is taken from
the fire; and, while it is yet hot, a small quantity of
plumbago is added, to give it a leaden colour. When
this is to be applied, the utensils must be heated to such
a degree, that the hand can scarcely be applied to them.
In this state the composition must be rubbed on them,
and afterwards wiped when the piece is dry.

Those who prepare small shot, make use of black lead
to polish and glaze it : the shot is rolled or agitated to-
gether with a quantity of plumbago. Plumbago is like-
wise used to make razor strops. When kneaded up with
clay, it forms excellent crucibles, which we receive from
Passaw in Saxony. One part of plumbago, three of ar-
gillaceous earth, and a small quantity of cows dung very
finely chopped, form an excellent lute for retorts. Mr.
Pelletier has used it with great advantage. This lute is
exceedingly refractory; and the glass will melt without
the covering changing its form.

To make the assay of an iron ore, I find the following
flux very advantageous:—I mix four hundred grains of
calcined borax, forty grains of slacked lime, two hundred
grains of nitrate of potash, and two hundred of the ore to
be assayed. I pulverize this mixture, and place it in a
lined crucible, which I cover. The heat of a forge fur-
nace is sufficient to effect the reduction. In the space of
half an hour, the button of metal is found deposited at
the bottom of the vitrified flux.

The process for working iron mines varies according to
the nature of the ore. The metal is sometimes so little
altered, and so abundant, that nothing more is necessary
than to mix it with the coal, and fuse it. This simple
and œconomical process forms the basis of the Catalan
method, which may be employed in treating the spathose
iron ores, those of Elbe, the hæmatites, and other rich
and pure ores. But it cannot be applied to such as con-
tain much foreign matter capable of becoming converted
into slag. For this reason, the experiments made in the
county of Foix on the ores of various countries, and vari-
rious qualities, have not succeeded. On this head, the

work of Mr. De la Peyrouse, and the memoirs of the
Baron de Dietrich, may be consulted.

The furnaces in which iron is fused, are from twelve to
eighteen feet in height.   Their internal cavity has the
form of two four-sided pyramids joined base to base.
The only flux added to the ore is the calcareous stone,
named (by the French) *castine*, if the ore be argillace-
ous; but if the gangue be calcareous, the workmen em-
ploy argillaceous earth, which is named *herbue*.

The furnace is charged at the upper part; and the fire
is excited by bellows, or hydraulic machines.   The ore
melts as it passes through the coal, and is collected at the
bottom, where it is maintained in a liquid state.   At the
end of every eight hours it is suffered to flow out into the
mould or hollow channel made in the sand.

Crude iron, cast in suitable moulds, forms chimney-
backs, pots, cauldrons, pipes, and an infinity of utensils
or vases, which could not be obtained without difficulty
by forging the iron.   The works which are established at
Creusot in Burgundy surpass every thing which can be
desired in this species of industry.

This first product is called Cast or Crude-Iron.   It is
brittle; but may be rendered ductile by heating it again,
and hammering it.   For this purpose the pig is fused
again, and stirred while in the state of fusion : after which
it is carried to the forge hammer.   By this treatment the
iron becomes ductile, assumes a fibrous texture, and
is formed into square or flat bars for the purposes of
trade.

Iron is likewise capable of a degree of superiority,
which is given to it by placing it in contact with coaly
substances, and softening it to such a degree that these
may penetrate into its texture.   It is then known by the
name of Steel.   We are indebted to Mr. Jars for very
interesting accounts of the steel manufactories in England.
The manufactory established at Amboise is not inferior to
those of England, as was ascertained by comparative ex-
periments made upon the products of the several manu-
factories, at Luxemburg, on Friday the 7th of Septem-
ber, 1786.

We may therefore divide the different states of iron
into cast or crude iron, iron properly so called, and

steel. It is clear that these three states are nothing more than modifications of each other; but the circumstances on which they depend, and the principle which establishes their difference, were till lately unknown.

The celebrated Bergmann has given an analysis of the various states of iron, and has drawn up the following table :

	Cast Iron.	Steel.	Iron.
Inflammable Air -	40	48	50
Plumbago - -	2 - 20	0 - 50	0 - 12
Manganese - -	15 - 25	15 - 25	15 - 25
Siliceous Earth -	2 - 25	0 - 60	0 - 175
Iron - -	80 - 30	83 - 65	84 - 45

This celebrated chemist has confirmed by his results the conclusion of Reaumur, who always considered steel as an intermediate state between crude and malleable iron.

We are indebted to three French chemists, Messrs. Monge, Vandermonde, and Berthollet, for a quantity of much more accurate information respecting all these states.

We may consider iron ores as natural mixtures of iron, oxigene, and various foreign substances. When an ore is wrought, the object of the operator is to clear the iron of all these matters. To effect this separation, the ore is thrown into the smelting furnaces, with different proportions of charcoal. These matters are heated together until they arrive at the hottest part where the mixture falls; and, after suffering the strong action of the fire, is precipitated in fusion, and forms a fluid mass at the bottom of the furnace. The earths and stones, nearly in a vitrified state, float above the fluid; and the oxigene, being partly driven out, remains likewise in a greater or less quantity in the crude iron. The crude iron is either white or grey, or black. In our inquiries concerning the cause of these three kinds of iron, and their qualities, we can refer them only to the proportions of foreign principles con-

tained in the crude iron.   These principles are carbone and oxigene.

1. Crude iron contains carbone.   The ladles which are used to agitate, take up, and pour out this melted metal, become covered with a coating of plumbago, which contains nine-tenths of carbone: and cast iron, strongly heated in contact with the coal, suffers a part to escape or exude from its surface when it is slowly cooled. Crude iron emits sparks when it is heated; the acids which dissolve it always leave a residue which is purely carbonaceous.   The hydrogenous gas, which is obtained by treating these irons with acids, always affords the carbonic acid by combustion.

2. Crude iron contains oxigene.   Several mineralogists attribute the fragility and brilliancy of crude iron to its still containing iron in the state of oxide.   This opinion, which is generally adopted, supposes the existence of oxigene.   Crude iron, urged by a violent heat in close vessels, affords the carbonic acid, and passes to the state of soft iron ; because its oxigene then unites to the carbonaceous principle, and constitutes the carbonic acid, which exhales, and clears the crude iron from the two principles which altered its quality.

Oxigene and carbone exist therefore in crude iron, but they may exist in three different states—1. A large quantity of carbone, and a small quantity of oxigene.   2. An exact proportion between these two principles.   3. Much oxigene, and a small quantity of carbone.—Now we find these three states in the three kinds of crude iron which we have distinguished, as is proved by analysis; and, as we may judge by the secondary processes, to correct these imperfections, or to convert crude iron to the malleable state.

1. In the first case, that iron which contains an excess of carbone is agitated or stirred as it flows out.   It is kept a long time exposed to the action of the bellows, and the smallest possible quantity of charcoal is made use of. We see that in this process the properest methods are used to facilitate the combustion of this excess of the carbonaceous principle.

2. In the second case, that kind of iron in which the principles exit in accurate proportions, requires only the

action of heat to unite and volatilize the two foreign principles. The crude iron is put into a state of ebullition by the disengagement of the acid which is formed, and exhales.

3. In the third kind, or that which contains oxigene in excess, the bellows are urged less violently ; and the metal is penetrated with coal in order to combine with the oxigene. Here therefore we see theory and practice go together. The former explains the usual manipulations, and affords us principles in cases wherein experiment too frequently fails.

Steel is a kind of iron which contains carbone only ; and its existence may be proved by all the experiments which have been mentioned as demonstrations that crude iron contains it.

Carbone may be given to iron—1. In the fusion of the ore. 2. Or, afterwards, by the cementation of iron with coaly substances.

1. In some parts of Hungary, and in the county of Foix, iron ores are wrought which contain the metal nearly in the disengaged state ; and the cast iron, when duly hammered, affords iron and steel in a greater or less quantity, according to the management of the fire, the quantity of air afforded by the tuyere, the quantity of coal made use of, and the nature of the ore. In this operation, the iron being scarcely at all calcined in the ore, becomes charged with coaly matter only, and the result is steel.

2. If the coaly principle be combined with iron in a ductile state, and deprived of all foreign matter, the combination being effected by cementation or otherwise, the iron will pass to the state of steel ; and the qualities of this steel will vary according to the proportions of carbone. The purity of the iron, and the care which is taken to avoid the oxidation of the metal, establish the various kinds of steel which are met with in commerce.*

* Cast steel may be made in the following manner : Take small pieces of iron, and place them in a crucible, with a mixture of the carbonate of lime and the earth of Hessian crucibles. The matters are to be exposed to the heat of a powerful air furnace. After the melting of the iron, it must be completely covered by the pow-

The nature and the principles of steel being once ad-mitted and established, the following facts will explain themselves.

1. Since steel contains no foreign principle but car-bone, it is not surprising that it remains unchanged by a violent heat in close vessels.

2. Steel, repeatedly heated, and exposed while hot to a current of air, loses its properties, and passes again to the state of soft iron.

3. Steel kept plunged for a time in crude iron in which oxigene predominates, becomes itself converted into soft iron.

4. Soft iron kept for a time plunged in crude iron, wherein carbone predominates, becomes converted into steel.

5. Iron, by passing to the state of steel, increases in weight one hundred and seventieth part.

Ductile iron would be a very soft metal, if it were cleared of all foreign substances.*

From all these facts we may conclude—1. That crude iron is a mixture of iron, carbone and oxigene. 2. That the products of crude iron are white, grey or black, ac-cording to the proportions of oxigene and carbone which it contains. 3. That the steel of cementation is merely a mixture of iron and carbone. 4. That steel which is over cemented, is an iron containing too large a quantity of carbone. 5. That iron would be a very soft metal, if it were not mixed with a greater or less quantity of oxi-gene and carbone.

Forged iron is distinguished into soft iron, and eager or brittle iron, by us (the French) called Rouvrain. This last has a coarser grain than the other : it is divided into red short iron, and cold short iron. The cause of this phenomenon is known : it arises from a phosphate of iron, which was discovered by Bergmann. This celebrated chemist constantly observed a precipitate to be formed in

dered lime and crucibles, to prevent its being acted upon by the ox-igenous portion of atmospheric air.

If the fire be well kept up, an hour will be sufficient to convert two pounds of iron into hard steel of an excellent quality, capable of being forged.—*Am. Ed.*

* The editor of this work has made iron tacks nearly as soft as lead, by transmitting hydrogen gas over them for several hours, confined in an earthen tube, and exposed to a red heat.—*Am. Ed.*

the solutions of cold short iron in the sulphuric acid. It was a white powder, which he called Siderite, and at first supposed to be a peculiar metal; but Mr. Meyer of Stetin has proved that it is a true phosphate of iron.

Soft iron does not afford it. All the irons of Champagne afford about a dram, or gros, in the pound of iron.

In order to obtain siderite, it is necessary that the solution should be saturated by a gentle heat on the sand bath. If the solution be made too quickly, the siderite is then mixed with ochre, which alters its purity and whiteness.

A precipitate is formed, which takes place so much the more speedily, as the solution is more diluted with water each time after filtration. The precipitate is formed in the first three or four days; a second is obtained towards the sixth day; and that which afterwards falls down is mixed with ochre.

Siderite may likewise be obtained by dissolving iron in the nitric acid, and evaporation to dryness. The iron is oxided by this first operation. More nitric acid being poured on this residue, dissolves only the siderite, without touching the oxide of iron. A second evaporation must then be made; and the residue must be diluted with water, to evaporate the last portions of nitric acid: and that which remains is siderite. It is soluble in the sulphuric, nitric, and muriatic acids, from which it may be precipitated by pouring into the solution as much alkali as is necessary to saturate the acid solvent. If the alkali be added in excess, ochre is then precipitated; and the result is a phosphate, and a salt arising from the union of the acid made use of and the alkali which has served for the precipitation.

The fixed and volatile alkalis, and lime water, decompose siderite. It is likewise decomposed by projecting it upon fused nitre.

When it has been precipitated by ammoniac, crystals may be obtained by evaporation, which when treated with powder of charcoal afford phosphorus. The ochreous precipitate affords iron by reduction; it is therefore a combination of the phosphoric acid and iron. Every solution of iron is precipitated in the form of siderite by the phosphoric acid.

The effect of the tempering of iron likewise deserves the attention of the chemist. I am of opinion that the hardness and brilliancy which iron acquires by this operation, arises from its integrant parts, which are separated by the heat, being kept and left at a certain distance from each other by the sudden cold, which drives out the heat, without bringing the constituent principles of the mass together. The iron is then more brittle, because the affinity of aggregation is less.

Iron is easily oxided. A bar of iron which is heated a long time in the forge furnace, becomes oxided at its surface; and the coatings of metal which pass to the state of oxide, are separated from the mass in the form of scales. The most degraded and the most altered metal, in the state when it is no longer attracted by the magnet, forms an oxide of a reddish brown colour, known by the name of Astringent Saffron of Mars, or the Brown Oxide of Iron.

The colour of this oxide varies according to its degree of oxidation. It is yellow, poppy-colour, or red; and is easily reduced into a black powder, when heated with coaly matters.

The combined action of air and water constitutes a martial oxide, known by the name of Aperitive Saffron of Mars. This composition is produced by the combination of oxigenous gas and carbonic gas with the iron. The exposition of the iron to a humid atmosphere rusts it speedily, and causes it to pass to the state of aperitive saffron of Mars. This preparation is a true carbonate of iron.

Water likewise acts upon iron. If iron filings be put into this liquid, and be agitated from time to time, the iron becomes divided, and blackens; and by decanting the turbid water, a black powder is deposited, which is called the Martial Æthiops of Lemery, or the Black Oxide of Iron. It is a commencement of calcination effected by the air contained in the water; but more especially by the decomposition of the water itself.

The fixed and volatile alkalis, in the fluid state, being digested upon iron, oxide a slight portion, which falls down in the form of æthiops.

All acids act more or less upon iron.

1. The concentrated sulphuric acid is decomposed by boiling upon this metal. If the mixture be distilled to dryness, the retort is found to contain sublimed sulphur, and a white mass, partly soluble in water, but incapable of crystallization.

But if the diluted sulphuric acid be poured upon iron, a considerable effervescence arises in consequence of the disengagement of hydrogenous gas. In this operation, the water is decomposed, its oxigene is employed to calcine the metal, while the hydrogene is disengaged; and the acid acts upon and dissolves the metal without being decomposed. This solution, when concentrated by evaporation, affords the sulphate of iron, which we have already treated of.

2. The nitric acid is decomposed rapidly upon iron. The solution is of a red brown colour, and suffers the oxide of iron to fall down at the expiration of a certain time. If new iron be plunged in this solution, the acid dissolves it, and lets fall the oxide which it held in solution.

If the solutions be concentrated, martial ochre of a red brown colour falls down. If the concentration be carried still further, a reddish jelly is formed, which is partially soluble in water.

Iron precipitated from its solution by the carbonate of potash, is easily dissolved by the superabundant alkali, and forms the martial alkaline tincture of Stahl.

Mr. Maret has proposed to precipitate the iron by the caustic alkali, to make the æthiops immediately. Mr. Darcet, in rendering an account of the process of Mr. Maret to the Royal Society of medicine, has proposed that of Mr. Croharé, which consists in boiling upon the iron water acidulated with the muriatic acid.

Mr. De Fourcroy made a course of experiments upon the martial precipitates, which throws much light upon the causes of the astonishing varieties observed in them. He has proved that the whole depends either on the nature of the acid, or the manner of operating at the time of making these precipitates, or the quality of the precipitant.

3. The diluted muriatic acid attacks iron with vehemence. Hydrogenous gas is disengaged, which arises from the decomposition of the water. If the solution be

concentrated and left to cool when it is of the thickness of
syrup, a magma is formed; thin flattened crystals are per-
ceived, which are very deliquescent.   The muriate of
iron, distilled in a retort by the Duke d'Ayen, exhibited
very singular phenomena.*   The first product was an
acid phlegm.   At a stronger heat, a non-deliquescent mu-
riate of iron sublimed, at the same time that very trans-
parent crystals rose to the roof of the retort, in the form
of the blades of razors, which decomposed the light in
the same manner as the best prisms.   At the bottom of
the retort there remained a styptic deliquescent salt, of a
brilliant colour, and a foliated appearance, which exactly
resembled the large plated talk, improperly called Musco-
vy Glass.   This last salt exposed to a violent heat, afford-
ed a sublimate more astonishing than the former products.
It was an opaque substance, truly metallic, which exhibited
sextons of hexahedral prisms, polished like steel.   It
was iron reduced, and sublimed.

4. It was long since known that iron is precipitated
from its solutions by vegetable astringent substances :†

* The muriate of iron has been recommended in cases of reten-
tion of urine, and has been used with success.   Ten drops of this
preparation given every ten minutes is a dose for an adult.—
Am. Ed.

† All vegetable astringent subtances do not precipitate iron of a
black colour from its solution in acids.   Those only which contain
the Gallic acid, have this effect   The astringent principle is com-
posed of the gallic, malic, or some other vegetable acid, united to a
substance which the Editor has taken for the earth of alum, and
which may be thrown down from infusions of astringent plants, by a
solution of potash.

The property which some vegetables possess, of striking a black
colour, with a solution of green vitriol, has long been regarded, as an
indubitable test of astringency, but this doctrine is false, for the fol-
lowing reasons.

First   Many vegetables contain the gallic acid, which are not
astringent to the taste.

Secondly.   The astringency of a vegetable may be destroyed by
triturating it with magnesia or the alkalis, and the mixture will
possess the property of producing a black colour, with solutions of
iron.

Thirdly.   If a small portion of the oil of vitriol be added to
an astringent vegetable, it appears to increase the astringency of it
to the taste, and yet the mixture will not precipitate solutions of iron
black.

Fourthly.   Many vegetables are astringent to the taste which have
no effect on solutions of iron.—*Am. Ed.*

and the black dyes, and the fabrication of ink, are founded on this known fact. But it was not till lately that an acid has been proved to exist in these substances, which combined with the iron, and which may be obtained from all these astringent vegetables*, either by simple distillation, or by mere digestion in cold water. The most simple process is the following:

Infuse one pound of powder of nut-galls in $2\frac{3}{4}$ pints of pure water. Leave the mixture together for four days, frequently shaking the infusion. Then filter, and leave the fluid in a vessel simply covered with blotting paper. The liquid becomes covered with a thick pellicle of mouldiness, and a precipitate falls down in proportion as the infusion evaporates. These precipitates collected, and dissolved in boiling water, form a liquor of a brown yellow colour, which, evaporated by a gentle heat, deposites—1. A precipitate which resembles fine sand. 2. crystals disposed in the form of a star. This salt is grey; and it is impossible to obtain it of a whiter colour by any repetition of solutions and crystallizations.†

It is an acid which effervesces with chalk, and reddens the infusion of turnsol.

Half an ounce of this salt is soluble in an ounce and a half of boiling water, or twelve ounces of cold water.

Boiling spirit of wine dissolves its own weight of this acid; but cold spirit dissolves only one-fourth.

* This is a mistake of the author.—*Am. Ed.*

† The following is one of the best methods of obtaining the acid of galls.

One ounce of the best Aleppo galls is to be boiled in sixteen ounces of water, until it is reduced to eight ounces. The extractive matter is to be separated from the acid, by mixing with the liquor, as much of pure aluminous earth, as would make two ounces of sulphate of alumine, and the liquor is to be filtered. The extractive matter, tannin, and all the heterogeneous bodies will remain on the filter, combined with the aluminous earth, while the gallic acid is dissolved in the liquor that passes through.

The Editor obtains the gallic acid by distilling to dryness in a glass retort, the expressed juice of the unripe fruit of the Dyospyros Virginiana, American Prune, Date plum, or Persimon tree. Water rises at first which must be thrown away, afterwards the gallic acid passes over into the receiver.—*Am. Ed.*

This salt is inflammable in the fire. It melts, and leaves a coal of difficult incineration.

When this acid is distilled in a retort, it becomes at first fluid, gives out an acid phlegm, but no oil; and, towards the end, a white sublimate rises, which attaches itself to the neck of the retort, and remains fluid as long as it is hot, but afterwards crystallizes. Much coal is found in the retort. The sublimate has nearly the taste and smell of acid of benzoin, is as soluble in water as in spirit of wine, reddens the infusion of turnsol, and precipitates metallic solutions with their different colours, and iron black.

The solution of the salt of the nut-gall, poured into a solution of gold, renders it of a dark green; and precipitates a brown powder, which is gold revived.

The solution of silver becomes brown; and at length deposites a grey powder, which is revived silver.

The solution of mercury is precipitated of a yellow orange colour.

The solution of copper affords a brown precipitate.

The solution of iron becomes black.

The solution of the acetite of lead is precipitated white.

This salt is changed into the oxalic acid, if the nitric acid be distilled from it.

The basis of ink consists of a solution of iron by the gallic acid. To make good ink, take one pound of nut-galls, six ounces of gum arabic, and six ounces of green copperas, with four pints of common water. The nut-galls must be bruised, and infused for four hours without boiling. The pounded gum must be first added, and suffered to disssolve; and, lastly, the copperas, which immediately converts the fluid to a black colour. Lewis, of the Royal Society of the London, made many researches on this subject; but he always returns to the forementioned substances. Powdered sugar is sometimes added, to render the ink shining.

5. The vegetable acid likewise dissolves iron with facility. It is this which holds the metal suspended in vegetables; and it may be precipitated from wine in the form of æthiops, by the means of alkalis.

Cream of tartar, or the acidulous tartrite of potash, likewise dissolves iron; and the various degrees of concentration of this solution forms the soluble martial tartar, the aperitive extract of Mars, and the balls of Nancy.

7. The solution of iron, by the oxalic acid, affords prismatic crystals of a greenish yellow colour, and a somewhat astringent taste, soluble in water, and efflorescing by heat.

8. Iron dissolved by the prussic acid, forms Prussian blue, or the prussiate of iron.

A singular mistake gave rise to the discovery of this substance. Diesbach a chemist of Berlin, being desirous of precipitating a decoction of cochineal with fixed alkali, borrowed of Dippel an alkali upon which he had several times distilled animal oil; and as the decoction of the cochineal contained sulphate of iron, the liquor immediately afforded a beautiful blue. The experiment being repeated was followed with similar results; and this colour became an object of commerce, under the name of Prussian Blue.

Prussian Blue was announced in the Memoirs of the Academy of Berlin in the year 1710, but without any account of the process, which was kept a secret until other chemists discovered it. The process was rendered public in the year 1724, in the Philosophical Transactions, by Woodward; who declared that he had received it from one of his friends in Germany.

To make Prussian blue, four ounces of alkali are mixed with the same weight of dried bullock's blood, and the mixture exposed in a crucible, which is covered in order to stifle the flame; the fire is kept up until the mixture is converted into a red-hot coal. This charcoal is thrown into water which is afterwards filtered, and concentrated by evaporation. The liquor is known by the name of the Phlogisticated Alkali. On the other hand, two ounces of the sulphate of iron and four ounces of the sulphate of alumine are dissolved in a pint of water. The two solutions are mixed, and a blueish deposition falls down, which is rendered still more intensely blue by washing it with muriatic acid.

Such is the process used in chemical laboratories; but in the works in the large way another method is follow- ed. Equal parts of the raspings of horns, clippings, of skins, or other animal substances, are taken and con- verted into charcoal. Ten pounds of this coal are mixed with thirty pounds of potash, and the mixture is cal- cined in an iron vessel. After twelve hours ignition, the mixture acquires the form of a soft paste, which is poured out into vessels of water. The water is then filtered; and the solution mixed with another, consisting of three parts of alum, and one of sulphate of iron.

I have likewise made Prussian blue by calcining and burning in the same vessel equal parts of the shavings of horns and tartar. I received the animal oil and the ammoniac, afforded by the calcination of these substances in large casks, which communicated with each other, and formed an apparatus after the manner of Woulfe.

It has likewise been observed that the tips of the thyme, the sun-flower, and several other vegetable sub- stances, when treated with alkali, communicate to it in a certain degree, the property of precipitating iron of a blue colour.

Much reasoning has been exhibited on the etiology of this phenomenon. Messrs. Brown and Geoffroy con- sidered Prussian blue as the phlogiston of iron, developed in the lixivium of blood. The abbé Menon imagined that the colour of iron was blue, and that the phlogisti- cated alkali precipitated it in its natural colour.

Mr. Macquer refuted the opinion of his predecessors in the year 1752; and proposed a system, in which he considers Prussian blue as iron supersaturated with phlogiston. This skilful chemist proved that the blue is not soluble in any respect in acids; and that the alkalis are capable of dissolving the colouring matter of the Prussian blue, and of becoming saturated with it to such a degree as to be no longer capable of effer- vescing.

Mr. Sage affirmed that the iron was saturated with the phosphoric acid; and the celebrated Bergmann likewise suspected the existence of some animal acid as is proved

by his notes on the lessons of chemistry of Scheffer. But it was reserved to the celebrated Scheele to convert these suspicions into certainty.

He has proved that the lixivium of blood, exposed for a certain time to the air, loses the property of precipitating iron of a blue colour; and he has shewn that this circumstance depends on the carbonic acid of the atmosphere, which disengages the colouring part. By adding a small quantity of sulphate of iron to this lixivium, it is no longer changed in consequence of its remaining in the carbonic acid. By boiling this lixivium upon an oxide of iron, it is likewise no longer capable of change in the carbonic acid. The iron has therefore the property of fixing and retaining the colouring principle; but it is necessary that it should not be in the state of oxide.

Prussian blue, treated in the way of distillation with the sulphuric acid, permits a fluid to escape that holds the prussic acid in solution, which may be precipitated upon iron.

The processes of Scheele, to obtain this acid in a state of purity, consist in putting two ounces of pulverized Prussian blue into a glass cucurbit, with one ounce of red precipitate, and six ounces of water. This mixture is to be boiled for some minutes, continually stirring it. It then assumes a yellow colour inclining to green. The fluid being filtered, two ounces of boiling water are to be thrown on the residue. This liquor is a prussiate of mercury, which cannot be decomposed either by alkalis or acids. The solution is then poured into a bottle, in which an ounce of newly-made filings of iron is put: three gross of concentrated sulphuric acid are to be added, and the whole agitated strongly for several minutes. The mixture becomes perfectly black by the reduction of the mercury; the liquor loses its mercurial taste, and exhibits that of the colouring lixivium. After suffering it to stand at rest for a time, it is decanted, put into a retort, and distilled by a gentle fire. The colouring principle passes first, because more volatile than water. The operation must be put an end to, as soon as one quarter of the liquor has passed over. As this product contains a small quantity of sulphuric acid, it may be cleared of it by re-distilling it from pulverized chalk by a very gentle fire. The prus-

sic acid then comes over in a state of the greatest purity. Scheele recommends that the vessels be well luted, because the acid would otherwise escape on account of its great levity. It is even of advantage to put a small quantity of water into the receivers, to absorb the acid; and it would likewise be very proper to surround them with pounded ice.*

This acid has a particular smell, which is not disagreeable; and its taste is sweet.

It does not redden blue paper; but renders the solutions of soap and of the sulphure of alkali turbid. Mr. Westrumb pretends that the prussic acid is the same as the phosphoric; for he obtained siderite from Prussian blue, and formed animal earth by mixing the lixivium of blood with a solution of calcareous earth.

The solution of iron in the prussic acid affords Prussian blue. We are indebted to Mr. Berthollet for a very interesting series of experiments upon the prussic acid, and its combinations.

The oxide of iron is capable of existing in two different states in combination with the prussic acid. If the oxide predominates, the combination is yellowish; but if its proportion be less, the product is Prussian blue. All the acids are capable of dissolving the portion or surplus of oxide which constitutes the difference between the first and second combination.

The prussiate of potash contains oxide of iron. If an acid be poured in, this oxide is dissolved, and is precipitated by double affinity in the form of Prussian blue. The

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* Prussic acid may be obtained in a state of purity, by pouring upon one part of Prussian blue, half as much sulphuric acid diluted with an equal quantity of water, and subsequent distillation. The prussic acid passes over in alcohol, placed in a receiver.

Mr. Schrœder, apothecary at Berlin, asserts that the prussic acid is contained in the aqua lauro cerasi, and the distilled water from the flowers of the peach tree, as likewise in the infusion of bitter almonds.

He was led to this discovery by observing, that the prussic acid has the quality common with those distilled waters and infusions of killing animals; and that the prussic acid, as well as the above-mentioned water, possesses the smell of bitter almonds. The author thinks it probable, that what has been hitherto called the narcotic principle, may be nothing but the prussic acid.—*Am. Ed.*

prussiate of potash made by a gentle heat, afterwards eva-
porated to dryness, then re-dissolved, and filtered, no
longer affords the blue upon the addition of acids. It
crystallizes in square plates with their edges cut slantways,
forming octahedrons, whose two opposite pyramids are
truncated. This solution of the prussiate of potash, when
mixed with the sulphuric acid, deposites Prussian blue, if
it be exposed to the solar light, or to a strong heat. In
these processes the prussiate of alkali may be entirely de-
composed; the prussiate of iron, when precipitated by the
action of the alkaline prussiate, carries down with it a no-
table proportion of alkali, of which it may be cleared by
washings, which contain the alkaline prussiate. It is the
same with regard to precipitations by the prussiates of
lime and ammoniac.

The prussiate of mercury crystallizes in tetrahedral
prisms, terminating in quadrangular pyramids, whose
planes answer to the angles of the prisms. Iron in its
metallic state decomposes the prussiate of mercury, and
deprives it both of its oxigene and its acid. The oxide
of mercury likewise decomposes the prussiate of iron and
seizes its acid. The prussiate of mercury is but imper-
fectly decomposed by the sulphuric and muriatic acids.
These acids form trisules, or triple salts, with it. The
precipitate of the nitrate of barytes by the prussic acid,
is not the compound which Bergmann supposed it to be,
but is merely a trisule.

The prussic acid readily precipitates alumine from its
nitric solution; the alumine nevertheless yields its prussic
acid to iron.

The oxigenated muriatic acid, when mixed with the
prussic acid, is again converted to the state of common
muriatic acid: the prussic acid assumes a more lively
smell, becomes more volatile, is deprived of its affinity
to alkalis and lime; it precipitates iron of a green colour,
and the green becomes blue if the precipitates be exposed
to light, or if it be treated with the sulphureous acid.

The prussic acid, impregnated with the oxigenated mu-
riatic acid, and exposed to light, assumes the smell of an
aromatic oil, is collected at the bottom of the water in the
form of an oil which is not inflammable, and rises in va-
pour by a gentle heat. By repeating this process it may

be totally decomposed; and then this species of oil be-
comes concrete, and is reduced into crystals.

The acid appears to have undergone a partial combus-
tion in this operation; at least the light and the sulphure-
ous acid do not restore it but by depriving it of oxigene.
The oxigenated prussic acid, mixed with lime or a fixed
alkali, becomes totally decomposed. Volatile alkali is
disengaged; and if the alkali was very caustic such as
the alcohol of potash, it becomes effervescent.

The prussic acid of Scheele is only decomposed in
part by this process; whence Mr. Berthollet concludes
that it is composed of hydrogene, nitrogene, and carbone.

These experiments do not prove that oxigene exists in
this acid. The water affords that which enters into the
carbonic acid, produced by the distillation of the prussic
acid. Prussian blue takes fire more easily than sulphur,
and detonates strongly with the oxigenated muriate of pot-
ash. The prussiate of mercury detonates still more
strongly with the nitrate of mercury. The gas of these
detonations has not yet been collected. The prussic acid,
combined with alkali and the oxide of iron, cannot be se-
parated by any acid without intervention of heat or light;
and when it is disengaged, it is no longer capable of se-
parating iron from the weakest acid, unless it be in the
way of double affinity. Mr. Berthollet thinks that the
elastic state of this acid diminishes this affinity; and that
it is necessary, in order that it may easily enter into com-
bination, that it should have lost some of its specific heat.
It is this which renders the oxigenated acid so feeble.

Prussian blue afforded me, by distillation, in the ounce,
one gross twenty-four grains of ammoniac, thirty-six
grains of the carbonate of ammoniac, four gross twelve
grains of oxide of iron, or alumine, and one hundred and
sixty-four inches of hydrogenous gas burning with a blue
flame.

The ammoniac comes over in combination with a small
quantity of the colouring principle, which it takes up, and
holds in solution: the sulphuric acid renders this visible.

Ammoniac heated upon Prussian blue decomposes it,
by seizing the colouring matter.

Lime-water digested upon Prussian blue dissolves the
colouring principle by the assistance of a gentle heat; the

combination is rapid, and the water acquires a yellow co-
lour. By filtration, the liquor passes of a fine bright yel-
low, no longer converts syrup of violets to a green, and
is no longer precipitated by the carbonic acid. It appears
to be completely neutralized, and affords an exceedingly
fine blue, when poured into a solution of the sulphate of
iron. The prussiate of lime has been proposed, by
Messrs. Fourcroy and Scheele, as the most accurate means
of ascertaining the presence of iron in any mineral water.

The pure fixed alkalis immediately discolour Prussian
blue in the cold. This combination produces heat; and
the pure alkalis ought to be preferred to the carbonates of
alkali in experiments of this nature.

Magnesia likewise seizes the colouring matter of Prus-
sian blue ;· but much more weakly than lime-water.

A mixture of equal parts of steel filings and nitrate of
potash, thrown into a crucible strongly ignited, detonates
at the end of a certain time, with the disengagement of
a considerable quantity of very bright sparks. The re-
sidue, when washed and filtered, affords an oxide of iron,
of a yellowish colour, known by the name of Zwelfer's
Saffron of Mars.

Iron decomposes the muriate of ammoniac very well.
Two gross of steel filings, and one gross of this salt, afford-
ed Mr. Bucquet, by distillation in the pneumato-chemi-
cal apparatus over mercury, fifty-four cubic inches of an
aëriform fluid; half of which was alkaline gas, and the
other half hydrogenous gas.

This decomposition is founded on the strong action of
the muriatic acid on iron.

One pound of the muriate of ammoniac in powder,
and one ounce of steel filings, sublimed together, form
the martial flowers, or Ens Martis. These flowers con-
sist merely of the muriate of ammoniac, coloured, and
rendered yellow by an oxide of iron.*

The oxide of iron decomposes the muriate of
ammoniac much better. This is an effect of double

* They consist of muriate of ammoniac and muriate of iron.
—*Am. Ed.*

affinity.　The ammoniac which rises is sometimes effer-
vescent.

A mixture of good filings of steel and sulphur, moist-
ened with a small quantity of water, becomes heated in
the course of several hours.　The water is decomposed,
the iron rusts, the sulphur is converted into acid, the
hydrogenous gas of the water exhales, and the heat is
sometimes sufficient to set the mixture on fire.　This
phenomenon constitutes the volcano of Lemery.

There is the strongest analogy both in the phenomena
and effects of the inflammation of this volcano, and the
decomposition of pyrites.

Sulphur combines easily with iron by fusion, and then
forms a true martial pyrites.*

Iron may be alloyed with several metallic substan-
ces; but the only alloy which is used in the arts is that
which it contracts with tin, to form white iron, or tin
plates.

To form the tin plates (commonly known by the name
of Tin in England), the softest iron is chosen, which is
reduced into very thin plates.　Care is taken to polish or
clean the surface very well; and this is done in several
ways.　The pieces are rubbed with sand-stone, and after-
wards kept for three times twenty-four hours in water,
acidulated by the fermentation of malt, turning them
from time to time.　They are afterwards cleaned, dried,
and are then ready for tinning.　Sal ammoniac is likewise
used in some manufactories.　For this purpose the plates
are disposed in a chamber, in which a certain quantity of
sal ammoniac is volatilized.　The salt forms a covering
over the whole surface of every plate, and possesses the
double advantage of clearing it from rust, and affording
the coaly principle necessary to prevent the calcination of
the metal.

When the iron is well cleared, the plates are plung-
ed vertically into a bath of tin, whose surface is covered
with pitch, or tallow.　They are turned in the bath; and

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* An easy method of combining iron and sulphur, is to give a bar
of iron a white heat, rub it with a roll of brimstone, and receive
the product in a bucket of water.—*Am. Ed.*

when taken out they are wiped with saw-dust, or bran.

The uses of iron are so very extensive, that there are few arts which can be practised without it. It is with jus-tice considered as the soul of all the arts. Some of its ores are used in their native state; such as the hæmatites, which is made into burnishers.

The sulphate of iron is the basis of all black colours, inks, &c.

The ochres are used by painters, under the name of Umber; and the brown red has the most extended use. With us (in France) it is applied to give a colour to brick pavements, to paint our doors and windows, to smear our casks, and to secure them from decay, and insects in sea voyages.

Cast iron is used to make boilers, chimney-grates, hearths, pots, &c. The instruments of agriculture are made of this metal: steel is used not only as steel; but its hardness renders it proper to cut and work the other metals.

The magnetical property of iron has led to the dis-covery of the mariner's compass; and this metal, if it were productive of no other advantage to mankind, would on that account be entitled to their greatest atten-tion.

Prussian blue is an agreeable colour, greatly esteemed, and much used.

Iron likewise furnishes the art of medicine with reme-dies. It is the only metal which is not noxious, and it has such an analogy with our organs, that it appears to con-stitute one of the elements of the human frame. Its effects in general consist in strengthening the stomach; and it appears to possess the property of passing in the circulation under the form of æthiops. The valuble ex-periments of Mr. Menghini, published in the Memoirs of the Institute of Bologna, have proved that the blood of persons who take martial remedies is thicker, and con-tains more iron. Mr. Lorry observed that the urine of a sick person, to whom he administered iron in a state of extreme division, was manifestly coloured with the nut-gall.

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CHAPTER XI.

Concerning Copper.

COPPER is a reddish metal, hard, elastic, sono-
rous, and affording a disagreeable smell by friction.
Its taste is styptic, and nauseous.   One cubic foot of
copper weighs five hundred and forty-five pounds.   The
specific gravity of cast copper not hammered is 7,7880.
—Brisson.

The alchemists distinguished this metal by the name
of Venus, on account of the facility with which it unites,
and is alloyed with other metals.

It may be reduced into very thin leaves, and drawn
into very fine wire.   The tenacity of this metal is such
that a wire of one tenth of an inch in diameter, is ca-
pable of supporting a weight of two hundred and ninety-
nine pounds four ounces, without breaking.

This metal is capable of affecting a regular form.   The
abbé Mongez observed it in solid quadrangular pyramids,
sometimes inserted into each other.

Copper is found in various forms in the bowels of the
earth.

1. Native copper.—This copper exists sometimes
in leaves in a gangue of quartz.   It is likewise found in
compact masses at Japan.   There is one of these pieces
in the royal cabinet, which weighs ten or twelve pounds.

Native copper is usually disseminated in a brownish
martial earth, susceptible of a polish.   When this ore is
rubbed with a flint, the traces appear of a beautiful cop-
per-colour.   Ores of this kind are found at Kaums-
dorf in Thuringia.—Sage, Analyse Chimique, t. iii.
p. 205.

We have likewise found native copper at Saint Sauveur.
It has the form of nodules resembling stalactites.   Most

of the native coppers appear to be formed by cementation, or by the precipitation of this metal dissolved in an acid, and thrown down by martial salts.*

* Copper in a native state is found in the counties of York and Lancaster, Pennsylvania; in Woodbridge, New Jersey, and on Lake Superior; and copper ore, in Berks county, Pennsylvania, and near the river Rariton, New Jersey; and a few miles from Baltimore, in Maryland; at Hill and Haines' iron works; on Cedar creek; on the East side of Broad river in South Carolina; on the James river, Virginia, and on the Oubash.

The following description of the Schuyler copper mine, drawn up by Mr. Benjamin Henry Latrobe, is extracted from the sixth volume, first hexade, p 319, of the Medical Repository of New York.

"The Schuyler Copper-mine, situated between the rivers Passaick and Hackinsack, near their confluence, in the state of New-Jersey, was discovered about the year 1719, by Arent Schuyler, grand-father to the gentleman of that name now living. The ore was found where it appeared on the side of the hill; was easily raised; and, as the policy of England at that time prohibited the establishment of smelting works or manufactories in her colonies, it was packed in casks, each containing about four hundred pounds, and exported, in its state of ore, to England.

It appears by his books, that, before the year 1731, Arent Schuyler had shipped 6953 casks, making about 1386 tons of raw ore, to the Bristol Copper and Brass Company. His son, Col. John Schuyler, prosecuted the work with more numerous and skilful hands. The quantity of ore raised by him is not known, as his books were lost during the war.

In 1761 the mine was leased to a company who procured the assistance of Mr. Hornblower the uncle of the present eminent steam-engineer, from England. They erected a steam-engine of the imperfect construction then in use. The engine-house, composed of combustible materials, was soon afterwards burned down. It was, however, rebuilt, and the mine was worked for four years with great advantage and profit. In 1765 a workman who had been dismissed set fire to the engine-house. It was again destroyed, and the works were discontinued by the company.

Several gentlemen in England, however, whose connexion with the company had taught them the superior quality of the ore of Schuyler's mine applied successfully to the crown for permission to establish works in America for smelting and refining copper; and an offer was made to Mr. Schuyler to purchase the whole estate containing the mine, for the sum of £100,000 sterling. This offer he refused, but agreed to join them in rebuilding the engine and working the mine. The disputes which arose about that time between England and America, and the consequent revolutionary war, put an end to the projected works; and the deranged state of the country previous to the adoption of the Federal Constitution in 1788, and other subsequent circumstances, occasioned the total neglect of this in every respect important mine, until the year 1793, when a company was formed, who undertook the work with new vigour.

Mr. Sage thinks that this metal may likewise be preci-
pitated from its solutions by phosphorus. To effect, says
he, the precipitation of copper by phosphorus, twelve
grains of this metal are to be dissolved in half a gross of
nitric acid.   The solution must be poured into half a
pint of distilled water, into which a cylinder of phospho-
rus, two inches long, weighing forty-eight grains, must
be plunged.   The surface becomes almost immediately
black, and is covered with particles of copper possessing
the metallic colour and brilliancy.   At the end of several
days, octahedral crystals are seen, whose insertions into
each other produce elegant dendrites; and at the end of
ten days the twelve grains of copper are completely re-
duced, as is proved by pouring ammoniac into the water.
If it do not exhibit a blue colour, it is a proof that the
fluid contains no copper.

2. Copper mineralized by sulphur forms the yellow ore
of copper.

They collected, at a very considerable expense, miners and smel-
ters from England and Germany; purchased a freehold estate con-
venient for the erection of furnaces and manufactories, with an excel-
lent stream of water; re-erected the engine; and began, and partly
completed the other works. At the instance of Mr. Longworthy,
an active member of the company, who, to great metallurgic know-
ledge and experience, and to much personal address, joined a spirit
perhaps much too unbounded in its projects, and far outstripping the
means and wants of our present population, an application was made
to Congress, in 1796, for an exclusive right to search for and work all
mines within the N. W. and S. W. territories, belonging to the
United States, for thirty years.   This monopoly was to descend from
mines of gold and diamonds down to clay-pits and slate quarries.
The application was not, and, perhaps, ought not to have been success-
ful. Soon afterwards one of the proprietors of the mine, who was a
principal shareholder in the company, died, and the whole interest of
the company has since been purchased by Nicholas I. Roosevelt.
No other has yet been wrought to effect in North America.

The ore of Schuyler's mine yields, in each hundred pounds of cop-
per, from four to seven ounces of silver, and like most copper ores, a
small portion of gold.   At the time when pure copper was sold in
England at £75 sterling per ton, the ore of Schuyler's mine was ship-
ped for England, at New-York, at £70 sterling per ton. This proves
the uncommon richness of the ore, and the small expense of con-
verting it into metal   An offer has been lately made by Messrs.
Bolton and Watt to purchase all the ore which can be raised, and to
enter into contract for that purpose.—*Am. Ed.*

This ore is of a golden colour, and the ignorant are often deceived by its flattering appearance. It contains a larger quantity of copper in proportion as the sulphur is less in quantity, and gives fewer sparks with the steel. It sometimes crystallizes in beautiful octahedrons. I possess two specimens covered over with trihedral pyramids of near an inch long, and between four and five lines in diameter at the basis.

When the sulphur is so abundant that the proportion of copper will no longer pay for the working, the ore is called Marcasite. The marcasite crystallizes in cubes or in octahedrons, which easily effloresce.

The yellow copper ore is found in various states according to the course of its decomposition. The first impression of hepatic vapours colours the surface in a thousand shades, in which state it is known by the name of Peacock's Tail, Pigeon's Neck, &c.

The last degree of alteration of this ore, effected by the simple disengagement of sulphur, forms the hepatic copper ore. The yellow colour is then converted into an obscure brown colour: this ore appears then to contain no other principles but water, copper, and iron, which last is always more or less abundant in these ores.

The yellow copper ore sometimes forms sulphate of copper in its decomposition. This salt is dissolved in water, and forms springs more or less loaded with it, from which the copper may be obtained by cementation. Old iron is thrown into the water; the copper is precipitated, and the iron takes its place. In this way it is obtained in Hungary, and we might use this œconomical process in several parts of our province. I have stalactites in my collection, sent me from Cevennes, which are coloured blue by a very considerable quantity of copper. In Gevaudan, at half a quarter of a league from St. Leger de Peyre, several springs of water impregnated with copper are found, which run into a valley. The inhabitants of this canton drink a glass of the water occasionally as a purgative.

The skeletons of animals are sometimes found in copper mines penetrated with that metal. Swedenburg has given an engraving of the figure of the skeleton of a qua-

druped taken out of a copper mine, and coloured by that
metal. In the royal cabinet there is a human hand, green
at the extremity of the fingers, the muscles of which are
dried and greenish. According to the report of Mr. Ley-
el, consul of mines, there was found at Fahlun in Swe-
den, in the great copper mine, a human carcase, which
had remained there forty years, with the flesh and bones
entire, without corruption, and without emitting any smell.
The body was clothed, and entirely incrusted with vitriol.
—Acta Literaria Suec. tri. i. anno. 1722, p. 250.

The turquoise stones are merely bones coloured by the
oxides of copper. Mr. De Reaumur, in the year 1725,
gave an account to the academy of the turquoises found in
Lower Languedoc. The colour of the turquoise fre-
quently becomes converted into green, which depends on
the alteration of the metallic oxide. The turquoise of
Lower Languedoc emits a fetid smell by the action of
fire, and is decomposed by acids. The turquoise of Prus-
sia emits no smell, and is not attacked by acids. Mr.
Sage suspected that the osseous part is agatized in these
last.

3. Grey copper ore.—The copper is mineralized by
arsenic. It has a grey colour, and an appearance nearly
vitreous. It usually contains silver ; and, when wrought
to extract this precious metal, it is called the Grey Silver
Ore. It affects a tetrahedral form ; and arsenic is the most
predominant of its principles.

4. The grey antimonial copper ore.—This differs from
the former, because it contains sulphur and antimony, and is
much more difficult to be wrought. When exposed to
the fire, it becomes as fluid as water ; the sulphur is vo-
latilized with the antimony and the arsenic. The residue
of the torrefaction is a mixture of the antimony and cop-
per, and sometimes it contains silver likewise.

5. Copper ores, in their decomposition, are reduced to
a more or less perfect state of oxidation. The carbonic
acid frequently unites to the metal, and becomes the mi-
neralizer. This substance is known by the name of Moun-
tain Blue, Azure of Copper, Mountain Green, Malachite.

A. The azure of copper crystallizes in rhomboidal te-
trahedral prisms, rather flattened, terminating in dihedral

summits : these crystals are of the most beautiful blue; they are frequently altered by exposure to the air, and become converted into malachite.

Mr. Sage has imitated the azure, both in the form and colour, by dissolving copper, in the cold, in water saturated with carbonate of ammoniac. When the azure of copper is of a less brilliant colour, and in the pulverulent form, it is called Mountain Blue.

B. The malachite, crystallized in octahedrons, has been found in Siberia. This ore is frequently striated, formed into small tufts of a silky appearance, or in very close parallel fibres. The malachite is frequently covered with protuberances. This figure appears to announce that it has been formed in the same manner as the stalactites.

Mountain green differs from the malachite only in its pulverulent form, and the mixtures which alter it. The alterations of the copper ores, and native copper likewise, produce a cupreous oxide, which bears the name of Red Copper Ore. The mine of Predanah, in the county of Cornwall, has afforded the finest specimens of red copper ore. The metal is nearly in the metallic state, and has the form of octahedral crystals. The granular red copper ore differs from this only in its figure. It sometimes has a brown martial earth for its gangue.

The azure, the malachite, and the red copper require no other process but mere fusion with coal to convert them into metal; the other kinds require to be cleared of their mineralizer by torrefaction, and afterwards to be fused with three parts of black flux.

To assay a sulphureous copper ore, Mr. Exchaquet proposes to make two gross of the crude ore, and one of the nitrate of potash; which, after pulverization, are to be detonated in an ignited crucible. The matter becomes hard after the detonation; upon which the fire is to be increased and kept up, in order that the sulphur may be dissipated. The fire is then to be still more strongly urged, until the ore enters into fusion; and a mixture of half an ounce of tartar, one quarter of an ounce of salt, and a small quantity of charcoal, is to be added in equal portions. An effervescence takes place at each projection of the mixture. The fire is then to be still more strong-

ly raised, and the crucible covered, and kept in this state for half an hour, in order that the copper may flow into a mass. In this way a very malleable button of copper is obtained.

The working of copper ores varies according to their composition. But, as the sulphureous ores are most commonly wrought, we shall confine ourselves to the process which is most suitable to their nature.

The metal is first picked or sorted; afterwards pounded in a mill, and washed to separate the gangue, and other foreign substances; it is then roasted, to drive off its mineralizer; and afterwards fused in the blast furnace. The result of this first fusion is black copper; which is again fused in the refining furnace, to dissipate all the sulphur which has withstood the preceding operations. When it is very pure, it is poured into a broad vessel, or test; a small quantity of water is thrown on its surface, which, being by that means cooled, separates from the rest, and is taken up. This is the copper in rosettes, which is taken to the hammer to be beat into proper form. The several operations are different in various places. In some countries the ore is roasted as often as eight times; in others, one or two are sufficient; and in some places it is not roasted at all. This variety depends—1. On the variations of practice : those who roast but little, employ more time and care in the fusion and refining. 2. On the nature of the ore : when it is rich in iron, the roastings are necessary to dispose this metal to fusion.

The method of roasting is likewise prodigiously varied. Pieces of the mineral are sometimes heaped up on a bed of combustible matter, and in this manner the calcination is performed; but, when this ore abounds with sulphur, it may be extracted by the ingenious process used at St. Bell, and described by Messrs. Jars in their excellent work.

The fusion is commonly performed in the blast furnace; but at Bristol, in England, the ore is roasted in a reverberatory furnace, and fused into black copper.

The refining furnace constructed at St. Bell, by Messrs. Jars, appears to me to be one of the best. They have published an excellent description of it, which may be consulted in their Mineralogical Travels. The refining

of copper consists in depriving it of the sulphur and iron which it may still retain. The sulphur is dissipated by fire, and bellows properly directed; and the iron is scorified by the assistance of some pounds of lead fused with the copper. The skilful mineralogists whom I have just quoted, make use of a reverberatory furnace, lined with charcoal; and fuse and scum their copper, without using lead.

When the copper contains a sufficient quantity of silver to admit of extraction, the following process is used:—1. Seventy-five pounds of copper are fused with two hundred and seventy-five of lead. The alloy is cast into flat pieces, which are called Loaves of Liquation. 2. These loaves are exposed to a heat sufficient to fuse the lead, which carries the silver with it, and leaves the copper, which, on account of its being more difficult to fuse, retains the original form of the loaves; and is every where penetrated by the interstices through which the fused metal made its escape; these are called Dried Loaves of Liquation. 3. They are carried into a second furnace, where they are exposed to a stronger heat, to deprive them of the small quantity of lead which they still retain. 4. The lead is afterwards taken to the cupel, where it is fused, and separated from all the silver it had taken up.

Copper is altered by long exposure to the air. Its surface becomes covered with a greenish coating, which is very hard, and known to the antiquarians under the name of Patin. This is the seal which attests the antiquity of statues and models covered with it.

Copper, exposed to the fire, becomes blue, yellow, and at last violet. It does not flow until it is strongly ignited. When in contact with the coals, it gives a blue greenish tinge to the flame; and, if it be kept a long time in fusion, part of it is volatilized.

When copper is heated in contact with air, it burns at its surface, and becomes changed into a blackish red oxide. This oxide may be separated by striking the plate which has been ignited, or by plunging it in water. When the oxide has been pounded, and more strongly calcined, it assumes a brown red colour, and may be con-

verted into a glass of a brown colour by a more violent heat.

1. The sulphuric acid only acts on copper when concentrated, and very hot. It then dissolves it, and easily affords blue crystals of a rhomboidal form. The sulphate of copper is known in commerce by the name of Blue Vitriol, Cyprian Vitriol, Blue Copper, &c.

Two methods are used to make the sulphate of copper which is met with in commerce. The first consists in calcining the cupreous pyrites, and causing them to effloresce, in order to develop the salt, which is then extracted by lixiviation. The second consists in forming this pyrites artificially, burning it, and lixiviating it, to extract the salt.

This salt possesses a very strong styptic taste. It is easily fusible by heat, which dissipates its water of crystallization, and changes its colour to a blueish white. The sulphuric acid may be extracted by a very strong fire. Lime and magnesia decompose this salt; and the precipitate is of a blueish white colour. If it be dried in the open air, it becomes green. Ammoniac likewise precipitates the copper in a whitish blue: but the precipitate is dissolved nearly at the same instant that it is formed; and the result is a solution of a beautiful blue colour, known by the name of Aqua Celestis.

This salt contains in the quintal thirty pounds acid, forty-three water, and twenty-seven copper.*

* Copper may be precipitated from the sulphate of copper by means of tin. The success of the experiment depends upon the heat of the solution, which must be at or near the boiling point, when the tin is added to it.

Prussiate of copper is made by precipitating a solution of blue vitriol, by the prussiate of potash.

It surpasses in intensity and beauty every brown paint now in use, with the additional advantage that by reason of its purple tint, it forms with white various shades of bloom or lilac colour, which do not appear liable to fade, like those which are formed by means of lake.

The editor of this work, prepared some prussiate of copper for Mr. Rembrandt Peale, a celebrated portrait painter of Philadelphia. The following is his opinion of this pigment. I have subjected the prussiate of copper to various trials, and have found it to be a valuable Pigment, in the fineness of its texture, quickness of drying and durability of colour, even exposed to the intense rays

2. The nitric acid attacks copper with effervesence, at the same time that it becomes decomposed, and emits abundance of nitrous gas.* When it is proposed to obtain this gas by the action of the acid upon the copper, it is necessary to have the precaution of weakening the acid, and to present the copper in pieces of considerable magnitude. If these circumstances be not attended to, the acid attacks the metal with such violence as suddenly to emit a prodigious quantity of gas; immediately after which an absorption takes place, and the water of the jar passes into the bottle. In this case ammoniac is formed. The diluted nitric acid perfectly dissolves copper : the solution is blue. If it be speedily concentrated, no other result is obtained but a magma without crystals; but if it be left exposed to the air, it affords crystals in long parallelograms. By leaving a solution of this kind to spontaneous evaporation, I have obtained rhomboidal crystals, which, instead of being blue, as they are usually described, are white. They decrepitate upon the coals, emit a red gas by mere heat, and nothing remains but a grey oxide.

3. The muriatic acid does not dissolve copper unless it be boiling and concentrated ; the solution is green, and affords prismatic crystals of considerable regularity when the evaporation is slow. This muriate is of an agreeable grass-green colour; its taste is caustic, and very astringent : it fuses by a gentle heat, and congeals into a mass; in which the acid is so adherent, that a very strong fire

of the sun, during several months. It is of a purple brown colour and therefore in combination with Prussian blue, produces a true black, of the most delicate texture and transparency. Possessing the *yellow* and *red* oxides of iron, the *blue* prussiate of iron, this purplish *brown* of the prussiate of copper, together with the *black* by combination ; we only want a *white* prussiate of some other metal or iron rendered white by the phosphoric or some other acid, to be in possession of a complete series of simple materials for painting, not liable to change by mutual decomposition nor the agency of light and air.—*Am. Ed.*

A mixture of sal ammoniac and blue vitriol, in equal proportions, dissolved in water, will produce a sympathetic ink. It is of a bright yellow colour when warm, and of a beautiful emerald green when cold.—*Am. Ed.*

* When pure and concentrated, it has no action on copper.— *Am. Ed.*

is required to disengage it.   It is very deliquescent.
Ammoniac does not dissolve the oxide of this muriate
with the same facility as it does that of the other cupre-
ous salts.   This observation was made by Mr. De Four-
croy ; which I think may be explained from the circum-
stance that the muriatic acid suffers the copper to be
precipitated in the metallic form, instead of giving out a
portion of its oxigene, which would facilitate the action of
the alkali.

4. The acetous acid, when made to act either hot or
cold upon copper, only corrodes it, and produces the sub-
stance known in commerce under the name of Verdigris.
The verdigris which is most used in the arts has been
long fabricated at Montpellier exclusively.   The prejudice
which prevailed, that the cellars of this city alone were
proper for this operation, preserved this commerce till late-
ly in its hands.   But the progress of information has suc-
cessively put it in the power of other countries to partake
in this manufacture.

The process used at Montpellier consists in fermenting
the refuse of grapes with sour wine.*   This refuse is af-
terwards laid in alternate strata, with plates of copper six
inches long and five broad.   In this state they are left for
a certain time ; after which they are taken out, and placed
edgewise in a cellar, where they are sprinkled with sour
wine : in this situation the verdigris swells up ; and is af-
terwards scraped off, put into sacks of leather, and ex-
ported to foreign countries.

Ready-made vinegar is used at Grenoble, and the plates
of copper are sprinkled with it.

The verdet or verdigris of Grenoble, contains one-sixth
less of copper : the vinegar which is obtained is stronger
and more abundant.   It has not the empyreumatic smell
of that of Montpellier.   The copper is therefore partly
dissolved in the verdet of Grenoble ; because it has
been first reduced into an oxide by the impression of the
vinegar, and afterwards attacked by the subsequent affu-
sion of the same acid.   It is therefore an acetate of
copper.

* Vinasse.

The oxides of copper, dissolved in vinegar, form a salt known by the name of Crystallized Verdigris, Crystals of Venus, Acetate of Copper.

To obtain this salt, the vinasse or sour wine is distilled; and this weak vinegar boiled on the verdigris. The solution is then conveyed into a boiler, where it is concentrated until a pellicle appears. Sticks are then plunged in the bath; and at the end of a certain number of days the sticks are again taken out, covered with rhomboidal crystals of a blue colour. These clusters of crystals, weighing each from four to six pounds, are wrapped up in paper, and distributed for sale.

The vinegar may be disengaged by distillation from these crystals; and the residue is a cupreous oxide, which possesses the characters of pyrophorus.

Vinegar, distilled on manganese, dissolves copper; which proves that it has taken up oxigene. The acetic acid, or radical vinegar, differs from ordinary vinegar, in containing a greater quantity of oxigene; and it is this oxigene which renders it proper to dissolve copper in the metallic state. The acetate of copper may likewise be formed by decomposing salt of Saturn, or sugar of lead, by the sulphate of copper. The sulphate of lead falls down; and the solution, when concentrated, affords the cupreous acetate.

5. The pure fixed alkalis, digested in the cold with filings of copper, become of a blue colour; but ammoniac dissolves it much more speedily. I put copper filings into a bottle with very caustic ammoniac, and kept the bottle stopped for two years: the copper was deprived of its colour, and became similar in appearance to a grey clay: whereas a similar vessel, in which I had placed the same mixture, but left open, soon afforded me very small blue crystals; and the whole concluded by affording only a hard stratum of green matter, resembling malachite.

Copper is precipitated from its solutions by iron. For this purpose nothing more is required than to leave the iron in one of the solutions of the other metal, which need not be strong. The phenomenon may be rendered very surprising, by pouring the solution of the sulphate of

copper upon the clean surface of a piece of iron; for this surface instantly becomes covered with copper. The copper obtained by this means, is known by the name of Copper Cementation.

This precipitation of one metal by another, has given rise to a belief that the iron was converted into copper: and I could, from my own knowledge, mention the names of individuals who have been imposed on by this phenomenon.

Copper mixes with most of the metals; and forms—

1. With arsenic, the white tombac.

2. With bismuth, an alloy of a reddish white colour, with cubic facets.

3. With antimony, a violet-coloured alloy.

4. It may be combined with zinc by fusion, or by cementation with lapis calaminaris. By the first process, similor, or the Manheim gold, is obtained; the produce of the second is brass.

5. Copper, plunged in a solution of mercury, assumes a white colour, which arises from the mercury which is displaced by the copper.

6. Copper is easily united with tin; and on this depends the art of tinning: for which purpose it is necessary to clean the surface of the metal perfectly; because the oxides do not combine with the metals. This first object is accomplished by rubbing the metal intended to be tinned with the muriate of ammoniac, or by scraping it effectually; or even by passing a weak acid over its whole surface. After this operation the tin is applied by fusing it in the vessel intended to be tinned, then spreading it about with old rags rolled up; and the oxidation of these metals is prevented by means of pitch.

Copper, fused with tin, forms bronze, or bell-metal. This alloy is more brittle, whiter, and more sonorous, in proportion to the quantity of tin that enters into its combination: it is then used to make bells. When it is intended to be applied to the purpose of casting statues, or forming great guns, a larger proportion of copper is used; because in this case solidity is one of the first requisites.

7. Copper and iron contract very little union.

8. Copper, alloyed with silver, renders it more fusible; and these two metals are combined to form solders.

Hence it is that verdigris is occasionally observed in pieces of silver, at those parts where joinings have been made by means of solder.

Copper precipitates silver from its solution in the nitric acid. This method is used in the mints to separate the silver from the acid, after the operation of parting.

Copper is very much used in the arts. All the boilers in dye-houses which are intended to contain compositions that do not attack this metal, are made of copper.

It is at present used as a sheathing for the bottoms of ships. All our kitchen utensils are made of it; and, in spite of the danger to which we are daily exposed of being poisoned, and notwithstanding the slow and destructive impression this metal cannot but produce upon us individually, there are few houses from which this metal is yet banished. It is a desirable object that a law might be passed to prohibit its use amongst us; as has been done in Sweden, at the solicitation of the Baron de Schoffer, to whom the public gratitude has erected a statue of the same metal. It is an allowable infringement of personal liberty, when government take upon them to direct the conduct of individuals in such a manner as to secure their own safety. There is no year passes in which several persons are not poisoned by hams, or other food which is suffered to remain in copper vessels.

Tinning is not a complete remedy against this danger; for it leaves an infinity of points where the copper is uncovered*.

The sulphate of copper is very much used in dying. The crystals of Venus, and verdigris, are likewise used in painting; they enter into the composition of colours, varnishes, &c.

The various alloys of copper with other metals, renders it highly valuable in the arts. Brass, bronze, and bell-metal, are very extensively useful.

* It may besides be doubted whether the extremely thin white coating, which conceals the internal surface of tinned copper, be not a kind of bell or speculum metal, instead of tin, as it is generally supposed to be. T.

CHAPTER XII.

Concerning Mercury.

MERCURY differs from all other metals, by its pro-
perty of retaining the fluid state at the ordinary
temperature of the atmosphere.

It possesses the metallic opacity and brilliancy; and
even acquires malleability when deprived of fluidity by a
proper degree of cold. The best ascertained experiment
which has been made on this phenomenon, was performed
by the Academy of Petersburg, in 1759. The natural
cold was increased by a mixture of snow and highly con-
centrated nitric acid; and the thermometer of De Lisle
was caused to fall to 213 degrees, which corresponds with
46 below 0 of Reaumur. At this period the mercury ap-
peared to descend no lower: the bulb of the thermometer
being then broken, the metal was found to be in a con-
gealed state, and bore to be flattened by the hammer.
Mr. Pallas congealed mercury, in 1772, at Krasnejark,
by the natural cold: he then found that it resembled soft
tin. It has been ascertained in England that the degree
of its congelation was the 32d of Reaumur. Mr. Mat-
thew Guthrie, consul at the court of the empress of Rus-
sia, proved that the degree of cold of this congelation was
32 degrees below 0 of Reaumur; and that, when the
mercury is purified by antimony, it congeals at 2 degrees
lower.*—See the Journal Encyclopédique, September
1785.†

Mercury is as indestructible by fire as gold and silver;
and its properties in general have caused it to be arranged
among the perfect metals.

A cubic foot of this metal weighs 949 pounds; and its
specific gravity is 13,5681.—Brisson.

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* Mercury may be easily frozen, by plunging it confined in glass
tubes, in a mixture of the muriate of lime and dry snow.—*Am. Ed.*

† For an account of this subject, see Dr. Blagden's History of the
Congelation of Mercury, in the seventy-third volume of the Philo-
sophical Transactions.

Mercury has been found in the earth in five different states.

1. Virgin mercury is found in most of the mines of this metal. Heat alone, or mechanical division of the ore, is sufficient to exhibit it in the metallic form.

Native mercury has been found in digging the foundations of some houses at Montpellier; and this metal has been constantly mixed and confounded with a grey or red clay, which forms a bed almost continuous, at a few feet beneath the foundation of this town.

The observations which I have had occasion to make on this subject, have ascertained that the mercury exists in a stratum of decomposed grit-stone, very argillaceous, ferruginous, and ochreous; of a red, brown, or grey colour. In this clay, the globules of mercury, in considerable abundance, were easily distinguishable, lying upon greyish plates. Traces are perceived which resemble dendrites; and its impressions are formed by layers of the oxide of mercury.

Several pounds of mercury have likewise been found in a well at Vienne in Dauphiny; and Mr. Thouvenel has pointed out to us three mines of this metal in the single province of Dauphiny, according to the indications of Bleton.

2. Mr. Sage read to the Academy, on the 11th of May 1782, the analysis of an ore of mercury, in the form of a solid oxide, which came from Idria in Friuli. It is of a brown red colour; and its fracture is granulated. It is reducible by mere heat; and affords oxigenated gas. It emits only half the quantity afforded by red precipitate; because this oxide contains metallic mercury. It affords ninety-one pounds of mercury per quintal, and a small quantity of silver.

3. The muriate of mercury, or corneous mercury, has been found native in the mine of Muschel-Lamburg, in the dutchy of Deux-Ponts. Mr. Sage obtained eighty-six pounds of mercury per quintal.

Mr. Woulfe has likewise discovered, in 1776, a very ponderous white, green, or yellow crystallized ore of mercury; in which he proved the existence of the sulphuric and muriatic acids.

4. Mercury is sometimes naturally amalgamated with other metals, such as gold, silver, arsenic, copper, &c.

5. Mercury is usually mineralized by sulphur; and the product is cinnabar or æthiops, according to the colour.

Cinnabar is found under different forms. 1. In red crystals, consisting of two triangular pyramids, truncated, and joined base to base, or else separated by a very short intermediate prism. Cinnabar has likewise been found crystallized in transparent plates.

2. Cinnabar is almost always found in masses, more or less compact; the colour varies from deep black to the brightest red. In this last state it is distinguished by the name of Vermillion.

Cinnabar has for its gangue, quartz, clay, calcareous earth, ponderous spar, and even coal. The ore which the Germans called Brandertz, has for its gangue a bituminous matter, which burns perfectly well; and it affords only six pounds of mercury in the quintal.

The principal cinnabar mines which are wrought in Europe, are those of the Palatinate and those of Spain. Mr. Sage informed us, in 1776, of the process used in the Palatinate; and we are indebted to Mr. De Jussieu for a description of the method used in Spain.

In the Palatinate, the pounded and sifted ore is mixed with one third of lime; and the mixture introduced into iron cucurbits, one inch thick, three feet nine inches long, one foot wide, with an opening of five inches. These vessels are disposed in a gallery. Forty-eight of these retorts being arranged in two parallel lines, a second row is placed above the first. To the neck of each cucurbit an earthen pot is adapted, which is one third filled with water, and accurately luted on. The gallery is heated at the two extremities; several apertures formed in the dome serve the purpose of chimneys; and the distillation is effected by a fire kept up for ten or twelve hours.*

This process was followed at Almadan till the year 1647, when the following was adopted, as being more simple and œconomical. The furnace is twelve feet high, and four feet and a half diameter within. At the distance of five feet and a half from the ground, is an arch upon

* The editor is in possession of a specimen of Cinnabar, found in Liberty-town, Maryland.—*Am. Ed.*

which the ore is disposed, and a fire is kindled in the ash-
hole. The sublimed mercury escapes through twelve
apertures formed in the upper part of the laboratory. To
these apertures, rows of aludels, inserted one in the other,
are adjusted and disposed parallel upon a terrace, which
terminates in a small building separated into as many
chambers as there are files of aludels. Each chamber
has a cavity in the middle, to receive the small quantity
of mercury which may arrive to that distance.

Every furnace contains two hundred quintals of cinna-
bar, and the fire is kept up for three days. The sulphur
which burns is disengaged in the form of sulphureous
acid, and escapes through small chimneys made in each
chamber. Every repetition of the process affords from
twenty-five to sixty quintals of mercury.

The mine of Almaden has been wrought from time im-
memorial. Its veins are from three to fourteen feet in
breadth; and their breadth is even larger where they join.
Hitherto no method has been discovered to fix mercury
but that of extreme cold. This metallic substance, natu-
rally fluid, is capable of rising even by a very moderate
fire; as is proved by an experiment of Mr. Achard, who
having left a dish containing twenty pounds of mercury
over a furnace which was daily heated, experienced a sa-
livation at the end of several days; as did likewise two
other persons who had not quitted the chamber. He es-
timates this heat at about eighteen degrees of Reaumur.
—Journal de Physique, October 1782.

It is dangerous to oppose the evaporation or dilatation
of this metal which is produced by heat.

In the year 1732 an alchemist presented himself to Mr.
Geoffroy, pretending he had discovered the means of fix-
ing mercury. He inclosed the metal in an iron box, and
this box in five others, which were placed in a furnace;
the explosion was so strong, that it burst through the
boards of the floor. Mr. Hellot has related a similar fact
to the Academy.

Mercury boils in the same manner as other liquids
when it is heated; and for this purpose it does not even
require a very considerable heat; the ebullition consists
merely in its transition to the vaporous state: for it may
be distilled like all other fluids, and by that means cleared
of its impurities. Boerhaave had the patience to distil

the same mercury five hundred times successively; and the metal suffered no other change, than that it afforded a grey powder, which required only trituration to convert it again into running mercury.*

Mercury is not easily changed in the air; but if the action of the air be assisted by heat, the mercury gradually loses its fluidity; and at the end of several months forms a red oxide, which alchemists have distinguished by the name of Precipitate per se. The apparatus made use of for this operation is a very large and very flat bottle, closed with a stopper, in which there is a capillary perforation. The mercury within the bottle by this means possesses the contact of air; and by disposing the apparatus upon a sand bath, and keeping up the state of ebullition in the fluid, the oxide may be obtained in the course of several months.

This oxide gives out its oxigene by simple heat, without any intermedium; and the mercury resumes its metallic form; one ounce affords about a pint. A quintal of mercury takes up about eight pounds of oxigene. The red oxide of mercury, exposed to heat, sublimes in close vessels, and may be converted into a very beautiful glass. I have observed this on all occasions when I have made the red oxide by means of the nitric acid, according to the process which I shall immediately describe.

It is certain that mercury upon which water is boiled, communicates a vermifuge property to that liquid, though the most accurate experiments of Lemery have shewn that the metal does not perceptibly lose weight; which proves that the principle taken up by the water is very fugaceous, and so light that it does not constitute any sensible part of the weight. Water which has remained for a certain time over mercury contracts a very evident metallic taste.

1. The sulphuric acid does not act upon mercury unless assisted by heat. In this case, sulphureous gas is disengaged; and a white powder falls down, the quantity of which becomes greater in proportion as the acid is decomposed. This oxide weighs one third more than the

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* The boiling point of mercury is between 600° and 700° of Fahrenheit's thermometer. Dr. Irvine states it at 672°, and Mr. Dalton at 660°, and Mr. Crichton at 655°.—*Am. Ed.*

mercury made use of. It is caustic : if hot water be poured on it, it becomes yellow; and if it be urged by a violent heat, it affords oxigenous gas, and the mercury resumes its natural form. This yellow oxide, obtained by means of the sulphuric acid, is known by the name of Turbith Mineral. It has long been considered as a sulphate of mercury. Mr. Baumé has proved that it does not contain a particle of acid; and it appears that the water which develops its yellow colour, seizes the small quantity of undecomposed acid which was mixed with the oxide. If the water which has been poured on it be evaporated, a salt is obtained in small, soft, and deliquescent needles, which may be deprived of their acid by the simple affusion of water. This fluid precipitates the mercury from them in the form of turbith.*

2. The nitric acid of commerce, at the strength of thirty-five degrees, dissolves mercury with violence, even without the assistance of heat. This solution is accompanied with the disengagement of a considerable quantity of nitrous gas; because it is necessary that the acid should reduce the metal to the state of oxide before it can act upon it. One part of the acid is consequently employed in disposing the metal for solution, and the other dissolves it in proportion as it is oxided. This is what happens when the sulphuric acid is digested upon a metal; one portion is decomposed, and reduces the metal into an oxide, while the other dissolves it.

The manner of effecting the solution of mercury in the nitric acid, has an influence on the properties of the mercurial nitrate. Bergmann has observed that the solution which is made slowly and quietly, without disengagement of nitrous gas, affords no precipitate on the addition of water; whereas that which is made by the assistance of

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* Turbith mineral is a sulphate of mercury.

If it is boiled ever so often in distilled water, the water will precipitate the muriate of barytes. If potash is digested with it, vitriolated tartar, or sulphate of potash will be formed.

If it is exposed to a red heat in a glass tube, oxigene gas will be procured. and sulphate of mercury of a white colour will sublime, and adhere to the sides of the tube.

The editor has proposed to employ a calx of mercury, prepared by boiling a solution of potash on turbith mineral, in order to procure oxigene gas, perfectly pure, as no azotic air can be procured, from an oxide prepared in this manner.—*Am. Ed.*

heat, and with loss of nitrous gas, affords a precipitate.
It appears that the nitric acid, assisted by heat, is capable
of becoming loaded with an excess of mercurial oxide,
which it lets fall when diluted with water.

The method of performing the solution, and the pro-
cess made use of to crystallize it, has an equal influence
upon the form of the crystals.   1. The solution made in
the cold, and left to spontaneous evaporation, affords cry-
stals which appeared to Mr. De Lisle to be octahedral py-
ramids, truncated near their base, and having the four
angles resulting from the junction of the bases of their
pyramids likewise truncated.   2. If the same solution be
evaporated, long and acute blades are obtained, laying
one upon the other, and striated obliquely across.   3. The
solution of mercury effected by heat, affords flat and acute
needles, striated lengthways.

The nitrate of mercury is corrosive; it detonates upon
coals when it is very dry, and emits a whitish flame of
considerable brilliancy.

The mercurial nitrate, heated in a crucible, is fused,
and emits a considerable quantity of nitrous gas together
with its water of crystallization.   The remaining oxide
becomes yellow; and at length assumes a lively red co-
lour, and forms the substance called Red Precipitate.   In
order to make a very fine red precipitate, the mercurial
solution must be put into a retort, and distilled until no
more vapours come over.   An additional quantity of ni-
tric acid must then be poured on the remainder, and like-
wise distilled off.   After three or four repeated distilla-
tions, a very beautiful precipitate is obtained in small cry-
stals of a very superb red colour.

The solution of mercurial nitrate forms mercurial wa-
ter.   It is of use to ascertain the presence of sulphuric
and muriatic salts in mineral waters.

The acids, the alkalis, the earths, and some of the me-
tals, likewise precipitate mercury from its solution in the
nitric acid.   These precipitates always consist of the ox-
ides of mercury in a greater or less degree of perfection,
according to which circumstances their colour is subject
to variation.   On this head, Lemery, Baumé, &c. may
be consulted.

Mr. Bayen has discovered that some of these precipi-
tates possess the property of fulminating, when mixed

with a small quantity of sublimed sulphur. This che-
mist has pointed out three—1. The precipitate of mercu-
ry from its solution in the nitric acid by the assistance of
the carbonate of ammoniac. 2. The precipitate of the
same fluid by lime-water. 3. The precipitate of the so-
lution of corrosive sublimate by lime-water. Half a gross
is to be triturated with six grains of sublimed sulphur.
After the detonation, a violet coloured powder remains,
which affords a fine cinnabar by sublimation.*

* Howard's fulminating mercury is prepared in the following
manner : Dissolve one hundred grains of mercury, in one ounce
and a half of nitric acid by measure. Pour the solution when cold
into two ounce measures of alkohol. Apply the heat of an Argand
lamp, until an effervescence takes place, when a precipitate will be
formed, which is to be immediately collected on a filter, well wash-
ed in pure water, and dried in a heat not exceeding that of a water
bath. One hundred grains of mercury, will yield one hundred and
thirty of the dry precipitate.

Brugnatelli informs us, that this fulminating compound may be
prepared without heat, by pouring upon Turbith mineral, about
four times its weight of alkohol, and five times its weight of nitric
acid. An effervescence will take place, and what remains behind
will be fulminating mercury.*

The editor has prepared this compound, by dissolving the cry-
stals of the nitrate of mercury in water, adding alkohol to the so-
lution, and then the nitric acid. An effervescence took place in the
cold, and the fulminating mercury was deposited in the form of a
white powder.

This preparation can be fired with the flint and steel. The flash
is quicker and more vivid than that of gunpowder. A train of it
several inches in length, is consumed in a single instant. It may be
fired by an electrical shock. No gun can confine a quantity of it,
sufficient to project a bullet, with a greater force, than an ordinary
charge of gunpowder. Ten grains of it is sufficient to destroy the
best pistol barrels, which cannot be burst by filling them full of gun-
powder. A few grains of it, placed upon an anvil, and struck with
a hammer, explodes with a sharp and loud noise.

The editor had a quantity of this preparation in an ounce vial, ly-
ing upon a table. The walking of a few gentlemen through the
room, caused it to explode.

Having placed a few grains on a copper plate, he laid a golden
eagle, or ten dollar piece over them, and applied the heat of an Ar-
gand lamp to the bottom of the plate, to flash the powder. The
gold was placed over the fulminating compound, to shew that the
mercury was revived when it was fired. When the flash took place,

* Philosophical Magazine, vol. xvi. p. 186.

3. The muriatic acid does not sensibly act upon mercury : but if it be digested for a long time upon the metal, it oxides it, and at length dissolves the oxide, as may be concluded from the experiments of Homberg, inserted in the volume of the Academy of Sciences for the year 1700.

The muriatic acid completely dissolves the mercurial oxides. When these oxides are nearly in the metallic state, or charged with a small quantity of oxigene, the muriate of mercury is formed. When, on the contrary, the oxide of mercury is saturated with oxigene, the oxigenated muriate of mercury, or corrosive sublimate of mercury, is formed.

Corrosive sublimate may be formed according to two methods ; in the dry way, or in the humid way.

To make this salt in the dry way, the operator may proceed in various manners.

1. Equal parts of dried nitrate of mercury, decrepitated muriate of soda, and sulphate of iron calcined to whiteness, are mixed together. This mixture being exposed to sublimation, the product which arises is corrosive sublimate.

2. Running mercury is used in Holland instead of the nitrate of mercury ; and the same results may be obtained by using any oxide of mercury whatever.

3. Equal parts of the sulphate of mercury, and the decrepitated muriate of soda, afford the same salt by sublimation. This process of Kunckel has been revived by Boulduc.

4. Mr. Monet assures us that he obtained corrosive sublimate by treating the dry muriate of soda, and a mercurial oxide, in the way of distillation in a retort.

If mercury be dissolved in the oxigenated muriatic acid, the solution, when concentrated, affords very fine

the copper was perforated, the eagle bent in various directions, and thrown against the ceiling, where it made a large hole.

The principal agents by which fulminating mercury produces its effects, are gas. and caloric very suddenly set at liberty, and mercury and water thrown into a state of vapour.

Mr. Howard supposes this preparation is composed of nitrous etherized gas, and oxalate of mercury, with excess of oxigene.— *Am. Ed.*

corrosive sublimate. It may likewise be obtained by pre-cipitating the mercury from mercurial water by the same acid, and evaporating the solution.

I have obtained very fine sublimate by presenting a mercurial oxide, sufficiently loaded with oxigene, to the ordinary muriatic acid. One pound of muriatic acid, at the strength of twenty-five degrees, poured upon one pound of red oxide by the nitric acid, discolours it, in a short time dissolves it with a violent heat; and this solution, diluted with water, and properly evaporated, affords from twelve to fourteen ounces of crystals of corrosive subli-mate.

The corrosive muriate of mercury has a styptic taste, followed by an exceedingly disagreeable metallic taste. When placed on hot coals, it is dissipated in fumes; when slowly heated in subliming vessels, it rises in pris-matic crystals, so much flattened, that their faces are scarcely distinguishable. The assemblage of these has induced authors to compare them to sword blades lying across each other.

This salt is soluble in nineteen parts of water; and when the solution is concentrated, it affords crystals simi-lar to those obtained by sublimation.

Barytes, magnesia, and lime decompose this salt. Half a gross of corrosive sublimate in powder, thrown into a pint of lime-water, forms a yellow precipitate. This flu-id is known by the name of Phagedenic Water.

Fixed alkali precipitates the mercury in an orange-co-loured oxide; and volatile alkali in the form of a white powder, which becomes brown in a short time.

The same muriatic acid, combined with a less perfect oxide of mercury, forms the mild muriate of mercury, or mercurius dulcis. This combination may likewise be made by two methods; by the dry, or the humid way.

1. In the dry way, four parts of corrosive muriate of mercury are triturated in a mortar with three of running mercury. When the mercury has disappeared, the mix-ture is put into phials, and sublimed three successive times, in order that the combination may be more accu-rate. This sublimate differs from corrosive sublimate by its insolubility in water, its insipidity, and the form of its crystals, which are tetrahedral pyramids, terminated by

four-sided pyramids.   To obtain this regular form, it
is necessary that the sublimation should be made at a
moderate heat; for, if the heat be sufficient to liquefy the
salt, the result is merely a crust, with no appearance of
crystals.   As the trituration of corrosive sublimate is dan-
gerous, on account of the powder which rises, Mr.
Baumé pours a small quantity of water upon the mixture.
This liquid accelerates the trituration, and prevents the
rising of the destructive powder.

Mr. Bailleau has proposed the incorporating of corro-
sive sublimate with water, and triturating it with running
mercury. The combination is completed by digesting the
mixture on a sand bath by a gentle heat.   The matter
becomes white, and requires only a single sublimation.
Whenever it is suspected that mercurius dulcis still retains
a portion of corrosive sublimate, nothing more is neces-
sary to be done than to triturate it, and pour boiling water
upon it: for by this means the whole of the soluble salt
which may have remained, is carried off.*

Mr. Baumé has proved that there is no intermediate
state between mercurius dulcis and corrosive sublimate.
If less mercury be added to the sublimate, a proportional
quantity of mercurius dulcis only sublimes, and the rest
rises in the form of corrosive sublimate ; if a greater quan-

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* The following method of preparing calomel is recommended
by the Editor.   Put any quantity of crude mercury into an iron pot,
and add to it an equal quantity of sulphuric acid.   Boil the acid
over the mercury, until a dry salt remains in the pot ; reduce this
to a fine powder, and mix it accurately with an equal quantity by
weight of sea salt, dried over the fire.

Fill oil flasks about two thirds full of this mixture ; or glass sub-
liming vessels, similar to the one in plate ii.   The bottoms of these
vessels should be eleven inches broad and very thin, the tops four
inches from the bottom, and the neck three inches high.

Expose these vessels in a sand bath, to a considerable degree of
heat for several hours, and corrosive sublimate will be obtained, and
found adhering to the upper sides of the glass vessels.   Reduce this
to a fine powder, and triturate every pound of it, with eight ounces of
crude mercury, until the globules of this metal disappear, then sub-
lime. Calomel may also be procured by adding fluid mercury, to the
mixture of sea salt and sulphate of mercury, and triturating them
together, and once subliming them.

The heat must approach to red, and the bottoms of the flasks
will frequently be found melted.   Several thousand weight of calomel
have been prepared in this city, in this manner.—*Am. Ed.*

tity of mercury be added than is necessary to convert the whole into mercurius dulcis the excess remains in the form of running mercury.

The same chemist has likewise proved, that a portion of the mercury is always lost at each sublimation; and that a small quantity of corrosive sublimate is formed, which arises from the alteration of the mercury. Hence it follows that the mercurial panacea, which is made by subliming mercurius dulcis eight or nine times, is a more suspicious remedy than the mercurius dulcis itself.

2. Mercurius dulcis may likewise be made by decomposing mercurial water by a solution of the muriate of soda. The white precipitate which is obtained may be sublimed, and forms an excellent mercurius dulcis. I communicated this process to the Society of Sciences at Montpellier two years before Mr. Scheele made it known.

The corrosive muriate of mercury differs therefore from the mild muriate by the state of its acid.

The mercurial oxides are equally soluble in the other acids.

3. A solution of borax, mixed with mercurial water, forms a very abundant yellow precipitate, which is nothing else but the combination of the acid of borax and mercury. A small quantity of this salt remains in solution, which may be obtained in brilliant crystals by evaporation.

4. The acetous acid likewise dissolves the oxide of mercury, and affords white foliated crystals.

Mercury precipitated from a solution of the acetate of mercury, combines with the acidulous tartrite of potash, and forms vegeto-mercurial water of Pressavin.

The acetate of mercury is the basis of Keyser's pills.

5. Mercury, artificially mixed with sulphur, forms the red or black sulphures, known, on account of their colour, by the names of Æthiops or Cinnabar.

To form the æthiops, or black oxide of mercury, three methods may be followed.

1. Four ounces of mercury may be triturated with twelve ounces of sublimed sulphur in a glass mortar. The result is a black powder, called Æthiops Mineral.

2. Four ounces of sulphur may be fused in a crucible, and one ounce of mercury extinguished in it. The mixture readily takes fire, but the inflammation is to be prevented; and the blackish residue being pounded, affords a greenish powder, which is a true æthiops.

3. The æthiops may be made by pouring the sulphure of potash upon mercurial water.

These æthiops afford by sublimations cinnabar, or the red sulphurated oxide. But in order to make it with a greater degree of accuracy, four ounces of sublimed sulphur are fused in an unglazed earthen pot, and one pound of mercury mixed with it by stirring or agitation. When these substances have combined to a certain degree, the mixture spontaneously takes fire, and is suffered to burn about a minute. The flame is then smothered, and the residue pulverized, which forms a violet powder, usually weighing about seventeen ounces five gross. This powder, being sublimed, affords a sublimate of a livid red colour; which, when pounded, exhibits a fine red colour, known by the name of Vermillion.

Three parts of cinnabar, mixed with two ounces of iron filings, afford very pure mercury by distillation, which is called mercury revived from cinnabar. Lime, the alkalis, and most of the metals, may be substituted instead of the iron.

Mercury amalgamates with most other metals. On this property is founded the art of water-gilding, or gilding upon metals, the tinning of glasses, the working of gold and silver mines, &c.

Mercury is likewise used in the construction of meteorological instruments, in which it possesses the advantage over other fluids—1. That it does not easily freeze. 2. It is more easily and gradually dilatable, according to the fine experiments of Messrs. Bouquet and Lavoisier. 3. It is very nearly of the same quality in different specimens.

Mercury may be used in substance as a remedy against the volvulus, and it has never been observed to produce

bad effects.   It is mixed with fat, to form unguents very much used in venereal cases.   These are prepared with one-third or half their weight of mercury, according to the exigence of the case.

The mercurial water is used as an escharotic.

The red oxides answer the same purpose.

The mild mercurial muriate is used as a purgative. It enters into the composition of pills which are used in venereal cases, with the intention of carying off the mor-bific matter by the skin.

The corrosive muriate of mercury is of very extensive use, more especially against venereal disorders.   This remedy requires skill and prudence ; but I have received it as the common opinion of all physicians of reputation, that it is the most powerful and certain remedy possessed by the art of medicine.   In a large dose it irritates the system, affects the stomach, occasions spasms in the lower belly, and leaves impressions which are difficult to be eradicated.

Cinnabar is used in fumigations, to destroy certain in-sects which attach themselves to the skin.   It is likewise used as a pigment.

CHAPTER XIII.

Concerning Silver.

SILVER is a metal of a white colour, possessing neither smell nor taste, nearly unalterable by fire, very ductile and tenacious.   A cubic foot of this metal cast weighs seven hundred and twelve pounds; the specific gravity of cast silver is 10 1752.   See Brisson.—It is found in the earth in five different states, which we shall proceed to consider.

1. Virgin or native silver.—Native silver is found in various forms.   1. In ramifications composed of octa-hedrons inserted one in the other.   This variety is known by most mineralogists under the name of Virgin Silver

in Vegetation. Four processes, indicated by Mr. Sage, are known for the crystallization of silver : amalgamation, reduction by phosphorus, reduction by copper, and fusion.

A detail of these four processes may be seen in his Analyse Chimique, book iii. p. 238, et seq.

Native silver is likewise found in small capillary, flexible, and intertwined threads. The decomposition of the red or vitreous silver gives rise to this species ; it may even be produced by a slow calcination of one of these ores.

Silver is likewise found in irregular forms ; either in small plates dispersed in the gangues, or in masses. Albinus reports in the Chronicle of the Mines of Misnia, that in the year 1478 a lump of native silver was found at Schneeburg, weighing four hundred quintals. Duke Albert of Saxony descended into the mine to see this surprising mass of silver, and had dinner served up upon it.

2. The vitreous silver ore, or silver mineralized by sulphur.—This ore is of a grey colour, and may be cut like lead. It crystallizes in octahedrons, or in truncated cubes, and is most frequently found of an indeterminate figure. The sulphur may be extracted by heat. It affords about sixteen pounds in the quintal.

When the sulphur is contained in a greater proportion in this ore, it becomes black, porous, and friable.

3. Red silver ore: silver mineralized by sulphur and arsenic.—This species crystallizes in hexahedral pyramids, terminating in an obtuse trihedral pyramid, with rhombic faces. It is frequently found in irregular masses of no determinate figure. It possesses the colour and transparency of the ruby.

Mr. Sage has obtained from this ore, by distillation, water, carbonic acid, and the sulphurated yellow and red oxides of arsenic. If this ore be calcined in a test, and the mineralizer be suffered to exhale, the residue is found to be in the metallic state, exhibiting contorted threads of silver at its surface. Part of the silver passes to the state of grey oxide in this operation.

4. White antimonial silver ore : silver and antimony mineralized by sulphur.—This ore is as white as silver; it is brittle, and of a granulated fracture. Sometimes it is found in hexahedral prisms, truncated and flat at each end : this kind is found in the principality of Fur-stenburg. When exposed to heat, it becomes as fluid as water, emits antimony and sulphur, and leaves the silver behind, together with an oxide of antimony. This semi-metal is cleared off by fusion, assisted by proper fluxes, and cupellation.

5. The corneous ore of silver, or muriate of silver.— This species is of a dirty yellow grey : it is soft, and may be easily broken or cut. A gentle heat causes it to flow : it sublimes without decomposition, is most fre-quently found of no regular form, but sometimes crystal-lized in cubes. The muriatic acid is its mineralizer. Mr. Woulfe has shewn that it likewise contains a small quantity of sulphuric acid.

6. Silver is also very frequently alloyed with various metals, such as lead, copper, bismuth, cobalt; and these ores are sometimes wrought on account of the quantity of silver they contain.

The manner of working a silver ore varies according to its nature ; but all the processes used in various coun-tries may be reduced to the following :

1. In Peru and Mexico the mineral is pounded, roasted, washed, and afterwards triturated with mercury in copper boilers filled with water kept at the boiling heat. The whole is agitated by means of a kind of mill. The amalgam is afterwards expressed in a skin ; then heated to drive off the remaining mercury ; after which process the silver remains alone.

This method is defective—1. Because the fire volatili-zes a portion of the muriate of silver which abounds in these ores. 2. The washings carry with them a portion of the oxide of silver. 3. The mercury does not amal-gamate either with the muriates of silver, or the sulphates of that metal.

2. When silver ores, mineralized by sulphur or arsenic, are to be wrought, they are roasted, pounded, washed, and fused with lead. This metal seizes

all the silver, from which it is again separated by cupellation.

3. When the silver ore is poor, it is fused with cupreous pyrites, and the mixture treated in the way of liquation.—See the article Lead.

To determine the degree of purity of the silver, a given weight of silver is supposed to be composed of twelve parts, called pennyweights; each pennyweight is divided into twenty-four grains. Silver, clear of all mixture, is said to be twelve pennyweights fine.

In order to assay silver, and to ascertain its degree of fineness, the regulation of the Court of Monies of France prescribes, that thirty-six grains of silver be taken, and wrapped in a plate of lead containing no fine metal, and then exposed to cupellation. From the loss which the button of silver that remains on the cupel has suffered, a judgment is made of the quantity of alloy. If the loss be one twelfth of the whole, the silver is said to be eleven pennyweights fine. The details relating to this operation may be seen in *L'Art d'essayer l'Or et l'Argent, par M. Sage.*

Silver may be rendered hard by mixing it with copper; and for this reason it is alloyed with that metal for silversmiths work, as well as for the coinage. The law permits one twelfth of alloy in silver money;* and it is this portion of copper which renders the solution of silver coin in the nitric acid blue.

Silver is not changed by the contact of air. A considerable heat is required to fuse it; but it may be volatilized by strong fire without alteration, as is proved by the capital experiments of the Academicians of Paris, made in the focus of the lens of Mr. Trudaine. This metal emits a thick fume, which whitens plates of gold exposed immediately over it.

Junker converted silver into glass, by treating it in a way of reverberation, after the manner of Isaacus Hollandus, in a very strong fire.

* The British coinage is 11 ounces 2 pennyweights fine. T.

Macquer, by exposing silver twenty times successively to the porcelain furnace of Seves, obtained glass of an olive green colour. It was likewise observed that this metal, when exposed to the focus of a burning mirror, presented a white pulverulent matter on its surface, and a greenish vitreous covering on the support upon which it was placed.

Though these experiments clearly prove that silver is capable of combining with oxigene, the difficulty which is found in effecting this combination, and the facility with which this air is disengaged from the oxides of silver, prove that there is but little affinity between these two substances.

If silver in a state of extreme division be presented to the concentrated and boiling sulphuric acid, sulphureous gas is disengaged: the silver is reduced into a white matter, which is a true oxide of silver; and contains a small quantity of sulphate, which may be obtained in small needles, or in plates formed by the union of these needles, lengthways, as Mr. De Fourcroy has observed. This salt flows by heat, and is very fixed. If silver be precipitated by metals or alkalis, these precipitates are reducible without addition.

The nitric acid dissolves silver with rapidity: much nitrous gas is disengaged.*   The solution is at first blue: but this colour disappears when the silver is pure; and degenerates into a green colour, if it be alloyed with copper. The nitric acid is capable of dissolving more than half its weight of silver. The solution then lets fall crystals in hexagonal, triangular, or square plates, which are called Nitrate of Silver, Lunar Crystals, Lunar Nitre, &c.

The solution of these crystals, generally known by the name of Solution of Silver, is very caustic. It colours the skin black, burns the epidermis, and so completely destroys its organization, that the spot disappears only by the renewing of the skin.

* When pure and concentrated it has no action on this metal. —*Am. Ed.*

The nitrate of silver melts on burning coals; but if it be exposed to a gentle heat, in earthen or metallic vessels, it liquefies, and may then be cast in moulds. This fused nitrate of silver forms the lapis infernalis. Care must be taken to pour it out as soon as it is fused; because other-wise the acid would be disengaged, the silver would be revived, and the lapis infernalis, or lunar caustic, would lose its virtue.

Lapis infernalis, made with pure silver, and pre-pared as above described, is whitish; whereas it is blackish when suffered to remain in fusion for any time.

Lapis infernalis is very frequently mixed with nitrate of copper. This fraud is reprehensible, be-cause it is an alloy which renders wounds of a bad character.

The lapis infernalis is used as an escharotic, and to cor-rode fungous excrescences.

Silver may be precipitated from its solution by lime-water, alkalis, and several metals. These last exhibit very important phenomena.

1. A plate of copper, immersed in a solution of silver diluted in water, precipitates the metal. It adheres at the moment of precipitation to the surface of the copper, where it forms a kind of moss. In proportion as the silver is precipitated, the water assumes a blue tinge; which proves that the copper is dissolved in the nitric acid, in the room of the silver. When the whole of the silver is disengaged, the water is to be decanted, the silver dried, and fused in crucibles, to be cast into ingots. This silver almost always retains a small quantity of copper; of which it may be deprived by cupellation with lead, which ren-ders the silver pure : this process is used in the mints, where the parting operation of gold from silver is per-formed. The first step consists in separating the silver by means of nitric acid; and this is afterwards precipi-tated by the addition of copper.

2. The silver is likewise precipitated by mercury. In this operation it amalgamates with a small quantity of the mercury, and forms tetrahedral crystals terminated by a tetrahedral pyramid, which crystals are articulated into each other. This arrangement gives them the form of a vegetation; and has caused the precipitate to be known by the name of the Tree of Diana, *Arbor Dianæ.* Lemery, Homberg, and other chemists, have successively published processess to produce this phenomenon; but that which has succeeded best in my hands, is described by Mr. Baumé. Six gross of the solution of silver, and four of that of mercury, both well saturated, are taken, and diluted with five ounces of distilled water. These are to be put into a conical vessel; and an amalgam of seven parts of mercury, and one of silver, is to be poured in. A multitude of small crystals instantly appear to disengage themselves from the surface of the amalgam, upon which new ones articulate themselves; and a vegetation is produced, which perceptibly rises under the eye of the spectator. To render this phenomenon more striking, I decant the exhausted water, and substitute fresh: by this means I can fill any vessel whatever with these vegetations. The mercury amalgated with the silver, in this operation, may be separated by means of fire.

The muriatic acid does not dissolve silver, but it speedily dissolves its oxides. The oxigenated muriatic acid dissolves silver.

To produce a certain and speedy combination of the muriatic acid with silver, this acid is to be poured into a solution of the nitrate of silver. A precipitate immediately falls down, which is known by the name of Luna Cornea. This muriate of silver is very fusible; and runs into a grey and transparent substance, considerably resembling horn. If a stronger degree of heat be applied, it is decomposed, part is volatilized, and the other part reduced into silver.

The muriate of silver, exposed to the light of the sun, becomes brown in a short time. Oxigenous gas is disengaged; which may be collected by placing it under water, according to the process of Mr. Berthollet.

Most of the solutions of the metals have the same pro-
perty. Lunar nitre likewise becomes coloured, and emits
its oxigene and nitrous gas.

One pound of boiling water does not dissolve more
than three or four grains of muriate of silver, accord-
ing to the observation of Mr. Monnet. The alkalis
are capable of decomposing the muriate of silver,
and separating the metal. The silver may be disengaged
from its muriate by fusion with three parts of black
flux.

Mr. Berthollet has taught us the following process, to
form the most dreadful and the most astonishing fulmi-
nating powder we have yet been acquainted with.
Take fine silver of cupellation; dissolve it in nitric acid;
precipitate this solution by lime-water; decant the water,
and expose the oxide for three days to the air. Mr.
Berthollet is of opinion that the presence of light has
some influence in the success of this experiment.

Mix this dried oxide in ammoniac, or volatile alkali,
and it will assume the form of a black powder: decant
the fluid, and leave the powder to dry in the open air.
This is the fulminating silver.*

Gunpowder, and even fulminating gold itself, cannot be
compared with this new product. The contact of fire is
necessary to cause gunpowder to detonate; and a deter-

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* This black powder, which has been represented by systematic
writers as the fulminating compound, has no such property, any fur-
ther than may be owing to the matter deposited from the alkaline so-
lution, during the exsiccation.

The alkaline liquor containing the fulminating silver ought to be
poured off from the insoluble powder, and exposed in a shallow ves-
sel to the air. In consequence of the exhalation, black shining
crystals form on the surface only, and soon join to form a pellicle.
As this pellicle adheres a little to the sides of the vessel, or maintains
its figure, the liquor may be poured off by a gentle inclination of the
vessel.

This liquor will yield another pellicle in the same way, but the
third or fourth pellicle will be paler than the former, and weaker
in the explosion.

The first pellicles, when slowly dried, explode by the touch of a
feather, or by their being heated to 90° of Fahrenheit's thermo-
meter.*— *Am. Ed.*

* Minutes of the Society for Philosophical experiments and conversations, p. 327.

minate degree of heat is required to cause fulminating
gold to fulminate : but the contact of a cold body is
sufficient to produce the detonation of fulminating silver.
In a word, this product, once obtained, can no longer be
touched : no attempts must be made to inclose it in a
bottle, but it must be left in the capsule wherein the eva-
poration was performed.

It is useless to observe, that the fulmination ought
not to be attempted but with small quantities ; the
weight of a grain, for example : for a larger mass
would give rise to a dangerous detonation. The ne-
cessity of making this preparation with the face covered
with a mask with glass-eyes, may be easily conceived.
It is prudent to dry the fulminating silver in small metal-
lic capsules.

The following experiment will complete the notion
which ought to be formed of the fulminating property of
this preparation.

Take the ammoniac which was used in the conversion
of the oxide of silver, into the black precipitate which
forms fulminating silver : put this ammoniac into a small
matrass of thin glass, and let it be subjected to the de-
gree of ebullition necessary to complete the combination.
Take the matrass from the fire ; and a rough covering
of crystals will be formed on its internal surface which is
beneath the fluid. If one of these crystals beneath the
cold fluid be touched, an explosion takes place which
breaks the matrass.

The process for obtaining fulminating silver being de
scribed, its effects known, and the cautions necessary for
repeating the experiment being well ascertained, we shall
speak a word concerning the theory of the phenomenon :
it is the same as that of fulminating gold, laid down by
Mr. Berthollet.—See the memoirs of the Royal Academy
of Sciences, for the year 1785.

In this operation, the oxigene, which adheres very slight-
ly to the silver, combines with the hydrogene of the am-
moniac. From the combination of the oxigene and the
hydrogene, water in the state of vapour is produced.
This water, instantly vaporized, and possessing all the
elasticity and expansive force of that state, is the principal

cause of the phenomenon; in which the nitrogene, which is disengaged from the ammoniac, with its whole expansibility, likewise bears a principal part.

After the fulmination, the silver is found reduced or revivified; that is to say, it has resumed its metallic state. It again becomes the same white, brilliant, and pure metal which it was when taken out of the cupel.*

The principal use of silver is in coinage, as the representative sign of the value of other commodities.

Its metallic brilliancy has caused it to be adopted as an ornament; its hardness, and unchangeableness in the air, renders it very valuable.

It is alloyed with copper, to form solder; whence it happens that silver utensils are subject to rust and verdigris, at the places where they are soldered.

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* Brugnatelli's mode of preparing a fulminating oxalate of silver is as follows.

" Take 100 grains of lapis infernalis in powder, and having put them into a beer glass, pour over them first an ounce of alcohol, and then as much concentrated nitric acid. The mixture becomes heated, enters into ebullition, and there is visibly formed ether, which is changed into a gaseous fluid. The matter gradually becomes milky and opaque, and is filled with small very white flakes : when the whole gray powder of the lapis infernalis has assumed this form, and when the liquor has acquired consistence, you must immediately add distilled water to suspend the ebullition, and to prevent the matter from being re-dissolved, so that nothing may be found but the solution of silver. Then collect the white precipitate on a filter, and suffer it to dry. This precipitate is fulminating silver : a little more than half the weight of the lapis infernalis employed is obtained. The detonating force of this preparation even in a much smaller quantity far surpasses that of fulminating mercury prepared according to the process of Mr. Howard. It detonates in a terrible manner when scarcely touched with a glass tube the extremity of which has been dipped in concentrated sulphuric acid, or even that of the shops. A grain of this fulminating silver put upon a burning coal made so loud a report that it stunned the by-standers. The same effect was produced by putting a little of the same preparation on an electric pile, with a piece of paper interposed, and making a spark pass through the middle of it by means of a metallic plate : the paper will be either perforated or torn."*Am. Ed.*

CHAPTER XIV.

Concerning Gold.

GOLD is the most perfect, the most ductile, the most tenacious, and the most unchangeable, of all the known metals. A cubic foot of pure gold, cast and not hammered, weighs 1348 pounds; and its specific gravity is 19,2581.—See Brisson.

Gold has neither smell nor taste ; its colour is yellow, and this varies according to the purity of the metal.

1. As gold is subject to very little alteration, it is almost always found in the native state ; and under this form it exhibits the following varieties :—1. It is found in octahedrons in the Gold mines of Boitza in Transylvania. These octahedrons are sometimes truncated in such a manner as to have the appearance of hexagonal plates. This native gold is alloyed with a small quantity of silver; which, according to Mr. Sage, gives it a pale yellow colour. It has likewise been found crystallized . in tetrahedral prisms, terminated by four-sided pyramids. The amalgam made with certain precautions is likewise capable of causing gold to assume a form nearly similar, according to Mr. Sage ; and gold reduced by phosphorus sometimes exhibits octahedral crystals.

Gold likewise crystallizes by fusion. Messrs. Tillet and Mongez obtained it in short quadrangular pyramids.

2. Native gold sometimes exhibits fibres or filaments of various lengths ; it is likewise found in plates disseminated on a gangue. The gold ore of Lagardet, a few leagues distant from Alemont in Dauphiny, is of this kind. 3. Gold is likewise found sometimes in small plates or spangles, dispersed in sand or earths : under this form it is found in the auriferous rivers, such as the Ariege, the Ceze, the Gardon, the Rhone. These small plates are

sometimes one line in diameter, but most commonly too small to be seen by the naked eye.   4. Gold is sometimes found in irregular masses; in which instance it is known by the name of Gold Dust. Very large pieces of this kind are found in Mexico and Peru.

3. Gold is sometimes mineralized by sulphur, by the means of fire. The auriferous pyrites are frequently found in Peru, Siberia, Sweden, Hungary, &c. To ascertain whether a pyrites contains gold or not, it must be pounded, and nitric acid poured upon it until it takes nothing more up. This solution must then be diluted with much water. The lightest insoluble parts may be carried off by washings; and the residue, upon examination, will shew whether it contains gold or not.

When the martial pyrites is decomposed, the gold is always disengaged; and it is probable that the small plates of gold in the auriferous rivers, are afforded by a decomposition of this kind.

Gold is sometimes mineralized by sulphur, with the assistance of zinc, as in the gold mine of Nagyag. This ore likewise contains lead, antimony, copper, silver, and gold.

4. Mr. Sage has given a description and analysis of an arsenical ore of gold.*

5. Gold likewise exists naturally in vegetables. Becher obtained it. Henckel affirmed that they contain it; and Mr. Sage has resumed this inquiry, and found it ac-

* Mr. Jefferson informs us, that he knew a single instance of gold found in Virginia, on the north side of the Rappahannoc river, about four miles below the falls. It was interspersed in small specks, through a lump of ore, of about four pounds weight, which yielded seventeen penny-weights of gold, of great ductility.*

Drayton says, a small bit of gold is said to have been once found in Greenville district, on Paris mountain, South Carolina, of sufficient quantity to be made into a ring.†

But the largest quantity of this metal in North-America, was discovered in 1803, in Cabarrus county, North-Carolina. It is found in a creek, which in the summer is dry, in small grains and considerable masses. The gold is mixed with black sand, schistus, quartz, and granite. Near twenty thousand dollars worth of this metal have been coined at the mint in Philadelphia.—*Am. Ed.*

* Jefferson's Notes on Virginia, p. 28.
† A view of South-Carolina, by John Drayton, p. 48.

cording to the following table, which expresses the quan-
tities of gold obtained from the quintal of the several
earths.

	Ounces.	Gross.	Grains.
Rotted manure (terreau)	0	1	56
Earth of uncultivated ground (terre de Bruyere,)	0	2	36
Garden mould	0	5	0
Mould of a kitchen garden manured with dung yearly for sixty years	2	3	40

These results were at first contested; but at present it
appears to be generally agreed that gold is obtained, but
in a less quantity. Mr. Berthollet obtained forty grains
and eight twenty-fifths of gold in the quintal of ashes.
Messrs. Rouelle, Darcet, and Deyeux likewise obtain-
ed it.

It is therefore a physical fact, that gold exists in vege-
tables.

The method of working the ores of gold is nearly the
same as that used with silver ores. When the gold is in
a native state, nothing more is required than to divide the
ore by the pounding mill, and afterwards to wash and
amalgamate it. If the ore be mineralized, it is torrefied,
pounded, washed, fused with lead, and afterwards cupel-
led. Eliquation is likewise used for poor ores.

Those persons who explore the gold in small plates dis-
seminated in the sand of certain rivers, are known in
France by the name of Orpailleurs, or Pailloteurs. The
pailloteurs of the river Uze, after having ascertained that
the earth is sufficiently rich to be wrought, place a table
of several feet in length, and about a foot and a half in
width, on the banks of the river with ledges round
three of its sides. Pieces of stuff with a long nap are
nailed on to this board; and the sand is thrown upon it,
and washed, to carry away the lighter particles. When
the stuff is sufficiently charged with the small particles of
gold, it is shaken into a vessel, agitated with water to
carry off the lightest sand, and afterwards amalgamated

with mercury.*   Mr. Ell has given us an ample account
of the process used in working the gold ores in Spanish
South America.   A sufficient quantity of water is pro-
cured to wash them.   A stream is made to carry off the
earth, and every lighter substance.   Negro slaves, dis-
persed on the banks, throw in fresh earth ; while others,
standing in the brook, work it about with their feet and
hands.   Care is taken to lay pieces of wood across the
current of the water, to retain the lighter particles of the
metal.   This work is continued for a month, and even
for years together.   When it is proposed to terminate it,
the water is turned off; and then, in presence of the mas-
ter, the workmen take up the sand with wooden vessels,
in the form of shallow funnels, of one foot in diameter, at
the bottom of which is an aperture of one inch in width.
This dish is filled with sand ; and by a circular motion
the lighter substances are caused to flow off, while the
heavier settle to the bottom.   The platina is afterwards
separated grain by grain, with the blade of a knife, upon
a smooth board.   The rest is amalgamated, first by
working with the hands, and afterwards with a wooden
pestle in mortars of guaiacum wood ; after which the mer-
cury is separated from the gold by fire.

The Baron de Born has reduced the method of working
all the ores of silver and gold to one single process.   The
account which he has given of this process in his work,
may be reduced to the following operations :

1. The mineral is pounded, divided, and sifted.

2. It is properly roasted.

3. It is mixed with muriate of soda, water, and mer-
cury ; and agitation is used to facilitate the amalga-
mation.

4. The mercury is expressed from the amalgam.

* For a very full account of the treatment of auriferous sands, the
following works may be consulted :—1. The Memoir of Mr. Reau-
mur on the Auriferous Sands of France, printed among those of the
Academy for the year 1718.   2. The Memoir of Mr. Guettard on
the Ariege, inserted in the volume for 1761.   3. The Memoir upon
the Gold which is obtained from the Ariege in the county of Foix,
by the Baron de Dietrich.   In this last work, the various processes
are discussed ; and this celebrated mineralogist proposes others
more œconomical and advantageous.

5. The expressed mercury is exposed to distillation.

6. The silver is refined by the cupel.

These operations were first executed at Schemnitz in Hungary, and afterwards at Joackimstal in Bohemia, in the presence of the greatest mineralogists in Europe, sent thither by the various sovereigns of Europe.

The muriate of soda is used to decompose the sulphates produced by the calcinations.

To determine the fineness of gold with accuracy, the purest is supposed to be twenty-four carats, and these carats are divided into thirty-second parts ; the carat is always represented by a grain poids de marc.

The law directs the operations to be performed upon twenty-four grains of gold, tolerates twelve, and prohibits six, on account of the difficulty of appreciating the divisions which result from these small quantities.

In the parting assay, very pure silver must be made use of. This is mixed with the gold in the proportion of four to one, which has occasioned the name of Quartation to be given to the process. Mr. Sage has found that two parts and a half of silver to one of gold form the mixture most proper for making the cornet of assay. The two metals are wrapped up in a thin piece of lead four times the weight of the gold, and this mixture is put into the cupel when it is very hot. The result of the cupellation is a button containing fine gold and fine silver. This is flattened, lamellated, and rolled up into a spiral ; put into a small matrass, and six gross or drams of pure nitric acid, at thirty-two degrees of concentration, are poured on it. As soon as the matrass is heated, the metal becomes brown, the silver is dissolved, and much red vapours are disengaged. At the end of fifteen minutes the solution is decanted ; and an ounce of very pure acid, rather more concentrated, is poured on, to carry away the last portions of silver. This solution is decanted, after a digestion of fifteen or twenty minutes ; at which period warm water is added, and the cornet is washed until the water comes off tasteless. It is then dried in a crucible, weighed, and the fineness judged by the diminution of its weight.

Schindlers and Schutler have maintained that gold always retains a small quantity of silver, which they have

called the Interhalt, or Surplus. Mr. Sage found a six-ty-fourth part of a grain in the best conducted assay.

In order to separate the silver which is dissolved in the nitric acid, this solution is diluted with a considerable quantity of water, and flat pieces of copper are plunged in it; which precipitate the silver, as we have observed in treating of the solution of silver.

Gold, exposed to fire, becomes red-hot before it melts. When melted it suffers no alteration*. Kunckel and Boyle kept it in a glass-house furnace for several months without change.

Homberg has nevertheless observed that this metal, ex-posed to the focus of the lens of Tschirnaus, smoked, was volatilized, and even vitrified in part. Mr. Macquer has verified this observation by the mirror of Mr. De Trudaine; he observed the gold fume, become volatilized, and covered with a dull pellicle, which constituted a vio-let-coloured oxide towards the middle.

Gold is not attracted by the sulphuric acid.

The nitric acid appears to have a real action upon it. Brandt is the first who announced the solution of gold by this acid. The experiments were made in the presence of the King of Sweden, and verified by his Academy. Messrs. Scheffer and Bergmann have confirmed the asser-tion of Brandt; and Mr. Sage afterwards published a se-ries of experiments on this subject. I am convinced, from my own experiments, several times repeated, that the purest nitric acid attacked gold in the cold, and dis-solved a sixty-fourth part of a grain. When very pure ni-tric acid is boiled upon gold equally pure, the solution may be ascertained in three ways—1. By the diminution of the weight of the metal. 2. By evaporation of the acid; in which case a purple spot remains at the bottom of the evaporatory vessel. 3. By the parting operation, by means of a plate of silver put into the liquor. In this case black flocks are in a short time disengaged, which consist of the gold itself. These phenomena appear to announce a true solution; and not a simple division or suspension, as was supposed.

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* Gold, when fused by a strong heat, is of a beautiful green co-lour during the fusion.

The quantity of gold dissolved appeared to me to vary according to the strength of the acid, the time of the ebullition, and the thickness of the metallic body.

The nitro-muriatic acid, and the oxigenated muriatic acid, are the true solvents of gold. These acids attack it with greater energy in proportion as they are more concentrated, and as the surface of the gold is larger. The solution may likewise be accelerated by heat.

This solution has a yellow colour, is caustic, and tinges the skin of a purple colour. If it be properly concentrated, it affords yellow crystals, resembling topazes, which affect the form of truncated octahedrons. These crystals are a true muriate of gold, according to Messrs. Bergmann, Sage, &c. If the solution of gold be distilled, a red liquor is obtained, which consists of the muriatic acid, coloured by a small quantity of gold which it has carried over. This fluid was distinguished by the adepts under the name of Red Lion.

Gold may be precipitated from its solution of several colours, according to the nature of the substances employed to make the precipitation. Gold is precipitated by lime and magnesia in a yellow powder, in which the gold exists nearly in the metallic state; a slight degree of heat only being necessary to convert it to that state.

The alkalis likewise precipitate gold in the form of a yellowish powder; and the precipitate is soluble in the sulphuric, nitric, and muriatic acids. These concentrated solutions suffer the gold to precipitate; crystals have not been obtained from them.

If ammoniac be poured on a yellowish solution of gold, the colour disappears; but, at the end of a certain time, small flocks are disengaged, which become more and more yellow, and gradually subside to the bottom of the vessel. This precipitate, being dried in the shade, is known by the name of Fulminating Gold; a denomination which it has obtained on account of its property of detonating, when gently heated.

Ammoniac is absolutely necessary to produce this effect.

The experiments of several chemists have taught us—
1. That, by gently heating fulminating gold in copper

tubes, one extremity of which was plunged in the pneu-
mato-chemical apparatus by the assistance of a syphon,
alkaline gas is obtained, and the precipitate is deprived of
its fulminating property : this fine experiment was made
by Mr. Berthollet. 2. Bergmann has observed that, by ex-
posing fulminating gold to a gentle heat, incapable of
causing it to fulminate, it becomes deprived of that pro-
perty. 3. When the gold is made to fulminate, in tubes
whose extremities are inserted under a vessel filled with
mercury, the product is nitrogene gas, and some drops of
water. 4. By triturating fulminating gold with oily sub-
stances, it is deprived of its property of fulminating.

From these established facts, it is evident that fulmi-
nating gold is a mixture of ammoniac and oxide of gold.
When this mixture is heated, the oxigene is disengaged
at the same time with the hydrogene of the alkali. These
two gases take fire by simple heat, detonate, and produce
water ; the nitrogene gas then remaining alone. From
these principles it ought to follow, that oily substances
which combine with the oxigene, acids which seize the
alkali, or a gentle and long-continued heat, which volati-
lizes the two principles without inflaming them, ought to
deprive this preparation of its property of fulminating.

The nitrous sulphur which Mr. Baumé supposed to be
formed, in his explanation of this phenomenon, does not
exist ; for the solution of the oxide of gold by the sul-
phuric acid, when precipitated by ammoniac, affords a
fulminating precipitate.

Gold is precipitated from its solution by several metals,
such as lead, iron, silver, copper, bismuth, mercury, zinc,
and tin. This last precipitates it instantly in the form of
a powder, distinguished by the name of the Purple Pow-
der of Cassius. This precipitate is much used in porce-
lain manufactories. Some very good observations on this
preparation may be seen in the Dictionary of Macquer.

Gold may likewise be precipitated from its solution by
ether : this liquor seizes the gold in a moment, and some-
times instantly revivifies it. I have seen the gold form a
stratum at the surface of the liquor, and the two fluids no
longer contained a particle.

The sulphures of alkali dissolve gold completely. No-
thing more is necessary for this purpose, than quickly to

fuse a mixture of equal parts of sulphur and potash with one-eighth of the total weight of the gold in leaves. This substance may then be poured out, pulverized, and dissolved in hot water. The solution has a yellowish green colour. Stahl affirms that Moses dissolved the golden calf by a similar process; and that, though the beverage must have been of a disagreeable taste, this circumstance was an additional reason for preferring the method, in order that the Israelites might longer retain their disgust for idolatry.

Gold unites with most of the metals.

Arsenic renders it brittle, as well as bismuth, nickel, and antimony. All these semi-metals render it white and eager.

Gold unites very well with tin and lead. These two metals deprive it of all its ductility.

Iron forms a very hard alloy with gold, which may be employed to much greater advantage than pure gold.

Copper renders it more fusible, and communicates a reddish colour to it. This alloy forms money, gold plate, and toys.

Silver renders it very pale. This alloy forms the green gold of goldsmiths.

Gold is employed for a variety of purposes. It is entitled, by the first rank which it holds among metals, to the most noble uses.

As its colour is agreeable to the eye, and is not subject to tarnish, it is used in ornaments, or as toys; for which purpose it is wrought into a thousand forms.

For some purposes it is drawn into very fine wire, and used in embroidery. For other purposes it is extended into leaves so extremely thin, that the slightest breath of wind carries them away : in this form it is applied upon wooden articles by means of size.

For other purposes it is reduced into a very fine powder, in which case it is called Ground Gold, Shell Gold, Gold in Rags, &c.

The ground gold is prepared by levigating the clippings of gold leaf with honey, washing them with water, and drying them with the particles which subside.

Shell gold consists of ground gold mixed with a muci-laginous water.

In order to make the gold in rags, pieces of linen are steeped in a solution of gold, afterwards dried, and then burned. When it is required to use them, a wet cork is dipped in wood ashes, and rubbed upon such articles of silver as are intended to be gilded.

For some purposes it is amalgamated with mercury. This amalgam is applied upon copper, the surface being previously well cleared. It must be spread very even, and the mercury driven off by heat. This forms the *or moulu*.

A coating of gilders wax is laid over the gold thus ap-plied. This is made with red bole, verdigris, alum, and sulphate of iron, incorporated and fused with yellow wax. The piece is heated a second time, to burn off the wax.

Gold was formerly used in medicine. This remedy was much in fashion in the fifteenth century. Its good-ness has at all times been proportioned to the dearness of the drug. Bernard de Palissy exclaimed strongly against the apothecaries of his time, who demanded ducat gold from the sick to put into their medicines, under the pretence that the purer the gold the more speedy would be the restoration of the health of the patient.

As this metal is highly valued, the rage of forming it constituted a known sect, under the name of Alchymists, which may be divided into two classes. The one very ignorant, frequently unprincipled, and most commonly uniting both qualities, suffered themselves to be imposed on by certain phenomena, such as the increase of weight of metals by calcination, the precipitation of one metal by another, and the yellow colour which some bodies, and certain preparations affect. They grounded their notions on certain vague principles concerning the formation of bodies, their common origin, their seeds, &c.

It is this sect which has caused alchymy to be defined, *ars sine arte, cujus principium est mentiri, medium la-borare, tertium mendicare.* These alchymists, after hav-ing been themselves the dupes for a considerable time, al-ways endeavoured to impose on others ; and there are a thousand tricks and impositions related of this class of men, which deserves only to be despised and pitied.

There is another class of alchymists which do not deserve to be made the object of public derision and contempt. This is formed of celebrated men, who, grounding their ideas on the received principles, have directed their researches towards this object. This class of men is valuable on account of their genius, probity, and conduct. They have formed a language, held scarcely any communication but with each other, and have at all times distinguished themselves by their austere manners, and their submission to Providence. The celebrated Becher is a name which alone suffices to render this sect respectable. The following passage, extracted from Becher, exhibits an idea of their language, and manner of proceeding in this study.

" Fac ergo ex lunâ et sole mercurios, quos cum primo ente sulphuris præcipita, præcipitatum philosophorum igne attenua exalta, et cum sale boracis philosophorum liquefac et fige donec sine fumo fluat. Quæ, licet breviter dicta sint, longo tamen labore acquiruntur et itinere, ex arenoso namque terrestri Arabico mari, in mare rubrum aqueum, et ex hoc in bituminosum ardens mare mortuum itinerandum est, non sine scopulorum et voraginum periculo, nos, Deo sint laudes, jam appulimus ad portum." Becher, Phys. Sub. i. s. v. cap. iii. page 461. in 8vo. *And elsewhere*, " Concludo enim, pro thesi firmissima, asinus est qui contra alchymiam loquitur, sed stultus et nebulo qui illam practicè venalem exponit."

The enlightened alchymists have enriched chemistry with most of the products which were known before the late revolution. Their knowledge and their indefatigable ardour put them in the situation of profiting by all the interesting facts which offered themselves.

God forbid that I should induce any person to enter into this path. I would use every effort to prevent any one from engaging in this research, so full of disappointment, and so dangerous to attach the mind to it. But I am of opinion that the alchymists have been too lightly treated ; and that this sect, which on many accounts is worthy of commendation, has not received the esteem and gratitude it is entitled to.

In addition to these reasons, I must observe that che-. mical phenomena become so wonderful; the torch of analysis has enlightened us to such an extent: we now decompose and reproduce so many substances, which ten years ago were considered with equal probability as indecomposable as gold is now thought to be; that no chemist can take upon him to affirm that we may not arrive at the art of imitating nature in the formation of metals.

CHAPTER XV.

Concerning Platina.

W E were unacquainted with platina until the year 1748. It is to Don Antonio Ulloa, who ac- companied the French Academicians in their famous voyage to Peru, to determine the figure of the earth, that we are indebted for our first notions of this metal.

Charles Wood, who had himself brought this metal from Jamaica, made experiments upon it, which are related in the Philosophical Transactions for the year 1749 and 1750.

Since that time, all the chemists in Europe procured this metal. Messrs. Scheffer in Sweden, Lewis in Eng- land, Margraff in Prussia, Macquer, Baumé, De Buffon, De Milly, De Lisle, De Morveau, have successively made researches on this substance; and we are indebted for great part of our present knowledge of this metal to the Baron de Sickengen.

Platina has hitherto been found only in the metallic state. Its form is that of small grains or flattened plates, of a livid white colour, intermediate between that of silver and iron : it is from this colour that it derived its name of Platina, or Little Silver. If the grains of platina be care-

fully examined, it is found that some of them are rounded, and others angular.

It has been found among the auriferous sands of South America, near the mountains of the districts of Novita and Cytara. These two metals are almost constantly accompanied by a ferruginous sand obedient to the magnet. The platina of commerce usually contains a small quantity of mercury, arising from the amalgamation which the ore has undergone in extracting the gold. When it is re-required to have platina in a very pure state, it must be exposed to heat, to drive off the mercury; and the magnetical parts, and the iron, must be sorted out with the magnet. Platina itself is slightly attracted by the magnet. M. L. affirms, in a Memoir read to the Academy of Sciences at Paris in the year 1785, that the lighter pieces of platina only are attracted by the magnet, and that they cease to be acted on when they exceed a certain size. The largest piece of platina which has been seen, is of the size of a pigeon's egg. It must be in the possession of the Royal Society at Bisca.

M. L. affirms that platina is malleable in its natural state; and he passed it through the flatting mill in the presence of Messrs. Tillet and Darcet.

Platina undergoes no alteration by exposure to the air; and fire alone does not even appear to possess the power of changing it. Messrs. Macquer and Baumé kept it several days in a glass-house furnace, without its grains having suffered any other change than that they were slightly agglutinated. It has nevertheless been ascertained that heat, kept up for a long time tarnishes its surface, and increases its weight. Margraff formerly made this observation.

Platina, exposed to the focus of the burning mirror of Mr. De Trudaine, fumes and melts. This metal may be hammered like gold and silver. It may likewise be fused upon charcoal, by the assistance of oxigenous gas. This substance resists the action of the acids, such as the sulphuric, the nitric, and the muriatic acids; it is soluble only in the oxigenated muriatic and the nitro-muriatic acids. One pound of the latter, digested on an ounce of platina, first assumes a yellow colour, then an orange colour, and lastly a very obscure brown. This solution

tinges animal substances brown; it spontaneously deposites small irregular fawn coloured crystals: but if it be concentrated, larger crystals are obtained, sometimes of an octahedral form, as Bergmann has observed. The muriate of platina is scarcely caustic, though sharp; it fuses in the fire, gives out its acid, and leaves an obscure grey oxide.

The sulphuric acid, poured on this solution, forms a precipitate of a dark colour; the precipitate occasioned by the muriatic acid, is yellowish.

The alkalis precipitate platina from its solution; but, if it be gradually precipitated by potash, the precipitate is dissolved by the alkali in proportion as it is formed.

A solution of the muriate of ammoniac, poured into a solution of platina, forms an orange-coloured precipitate, which is a true saline substance, totally soluble in water. This precipitate has been fused by Mr. De Lisle in a common fire (of a furnace). The result of the fusion is platina, still altered by some portion of saline matter; for it does not acquire ductility but by exposure to a much stronger heat.

The property which the muriate of ammoniac possesses of precipitating platina, affords a very simple method of ascertaining the mixture of this metal with gold: so that the fear of this alloy, which had alarmed the Spanish ministry so much as to occasion them to forbid its being wrought, does not at present exist, as we possess a simple method of ascertaining the fraud: and it is much to be wished that this very precious metal should be restored to the arts, to which it cannot but be very useful, by its brilliancy, its hardness, and its unchangeable nature.

The process of Mr. De Lisle to fuse platina, was published in 1774. Mr. Achard published a simpler method, nearly at the same time: it consists in taking two gross of platina, two gross of the white oxide of arsenic, two gross of the acidulous tartrite of potash, and putting them into a crucible well luted. This is to be exposed for an hour to a violent fire, which fuses the platina; but it is brittle, and whiter than ordinary platina. It is then to be exposed to a considerable heat under a muffle; by which means all the arsenic which was combined with the platina is dissipated, and this metal left in a state of pu-

rity. Vessels of platina may be formed, by filling clay moulds with the alloy of platina and arsenic; and exposing the mould in the muffle, to dissipate the semi-metal.

Mr. De Morveau substituted the arseniate of potash to advantage, instead of arsenic; and he had already fused platina with his vitreous flux, made of pounded glass, borax, and charcoal.

Mr. Pelletier fused platina, by mixing it with phosphoric glass and charcoal. The phosphorus then unites with the platina; and the phosphure of platina is exposed to a degree of heat sufficient to volatilize the phosphorus.

Mr. Baumé advises to fuse platina with a slight addition of lead, bismuth, antimony, or arsenic; and to keep the alloy in the fire a long time, to dissipate the metals which have facilitated the fusion.

Platina may likewise be fused with a metal soluble in an acid: the mixture being pulverized, the alloyed metal may be dissolved; and the powder of platina may then be fused with the flux of De Morveau.

Instead of using a soluble metal, a calcinable metal may be employed, and treated as before.*

* " Jeannety of Paris has succeeded in working platina into wire, plates, and vessels of different kinds, adapted chiefly to chemical purposes. The following account of his process was given in a report by Pelletier.*

" The crude platina is triturated with water, to remove any particles of iron, or other impurities mixed with it. One pound and a half of it are mixed with three pounds of white arsenic, and one pound of purified potash; a crucible capable of containing 20 pounds is placed in a furnace. so as to be well heated; and a third part of the above mixture is thrown into it; after applying to this a strong heat, a second portion is thrown in, and afterwards the remaining part, care being taken to mix the whole by stirring with a rod of platina. The heat is raised, and when the whole is thoroughly melted, the crucible is withdrawn, and allowed to cool. The metallic mass thus obtained is magnetic: it is broken and melted a second time in the same manner: and if this second fusion does not free it sufficiently from iron, it is fused a third time, though in general two fusions are sufficient. The first stage of the operation being finished, crucibles are taken, the bottoms of which are flat, and the circumference such as to give a mass of metal three inches and a quarter in diameter: they are raised to a red heat, and into each is thrown a pound and a half of the metallic substance obtained in the former part of the process, with an equal weight of arsenic, and

* Mémoire de Chimie, tom. ii. p. 123.

The cubic foot of crude platina weighs 1092 livres 1
ounce 7 gross 17 grains ; platina purified and fused weighs
1365 livres ; and purified platina forged weighs 1423, 8,
7, 64.

half a pound of potash : the heat is raised so as to melt this com-
pletely : the crucible is then withdrawn, and allowed to cool, placing
it horizontally, so that the bar of metal shall be of equal thickness.
The bars thus obtained are placed in a furnace under a muffle,
which ought not to be higher than the circumference of the bars
placed on edge, and inclined a little towards the sides of the muffle ;
three bars are placed on each side of it ; the fire is raised until the
muffle be equally heated through its circumference ; and whenever
the metallic bars begin to exhale vapour, the doors of the furnace
are closed to preserve the heat at the same degree, it being necessary
that it should be kept so to the end, as, if suddenly raised high, the
whole operation would be defeated. The bars are exposed to this
heat for six hours, their places being changed occasionally, that they
may be heated as equally as possible. They are then put into com-
mon oil, and are exposed for the same length of time to a heat suf-
ficient to dissipate the oil in vapour. This operation is continued as
long as any vapour arises from the bar ; and when this has ceased, the
heat is pushed as far as it can by the medium of the oil,—a step of
the process without which the platina is not obtained perfectly
malleable Lastly, when these operations have been finished, which,
when they have been properly executed, require about eight days,
the bars are cleansed with nitrous acid, and are boiled in distilled
water, to remove any adhering acid : they are then placed one
above another, and exposed to the strongest possible heat, and beat,
the heat being at first applied to them in a crucible, that no foreign
matter may be introduced into the spongy substance of the bars.
They are lastly heated in the naked fire, and formed into a square
bar, which is hammered for a longer or shorter time according to
its size.

" A process given by Moussin Poushkin, appears more easy of
execution than that of Jeannety, and 'will probably afford the platina
equally pure. The precipitate of platina from nitro-muriatic acid
is to be washed with cold water, and reduced, by exposure to heat
in a crucible, to the spongy metallic substance, which is usually ob-
tained by this operation. This is to be washed two or three times
with boiling water, to carry off any adhering saline matter. It is
then to be boiled for half an hour in so much water mixed with one-
tenth of muriatic acid, as will cover the mass to the depth of about
half an inch in a glass-vessel ; this removing any quantity of iron that
might exist in the metal. This liquid is to be poured off, the pla-
tina edulcorated and ignited To one part of this metal, two parts
of quicksilver are to be added, and they are to be amalgamated in a
glass or porphyry mortar ; mixing them in small quantities at a
time, as two drachms of mercury to three of platina, and adding to
this amalgam alternately small quantities of platina and mercury,
until the whole quantities are combined. In this way, and with pla-

Most of the neutral salts have no perceptible action upon platina. The results of several curious experiments may be seen in the Memoirs of Margraff.

The nitrate of potash alters platina, according to the experiments of Lewis and Margraff. Dr. Lewis, by heating a mixture of one part of platina and two parts of this nitrate, during three times twenty-four hours, observed that the metal assumed a rusty colour. By diffusing the mixture in water, the alkali was dissolved; and the platina, deprived of all the soluble matter, is diminished one-third. The powder taken up by the alkali is the oxide of iron, mixed with the oxide of platina.

These experiments, as likewise the property which platina possesses of being acted on by the magnet, prove that it contains iron; and Mr. De Buffon has concluded that this metal is a natural alloy of gold and iron. But it has been objected that the artificial alloy of these two metals, made in every possible proportion, never resembles platina; that this metal departs more from the properties

tina in this state, the amalgamation is easily effected. When the amalgam has been completed, it must be quickly moulded in bars or plates, of at least half an inch in thickness, and of such a length as to allow of their being easily managed in the fire. Half an hour after these have been formed, they begin to harden by the oxidizement of the quicksilver. As soon as they have acquired the proper degree of hardness to be handled without breaking, which commonly takes place in a little more than an hour, they are to be placed in a furnace, and kept ignited under a muffle. The quicksilver is thus expelled, and the platina remains perfectly solid, so that after being strongly ignited two or three times before the bellows, it may be forged or laminated in the same manner as gold or silver.[*]

"A very simple process has also been lately given by Mr. Tilloch. It consists in exposing the precipitate from the solution of platina in nitro-muriatic acid, by muriate of ammonia, to such a degree of heat as will volatilize the saline matter, and inclosing it after this in a piece of platina already malleable, and which has been spread out by the flatting mill. The envelope is then exposed to a sufficient temperature, and, while hot, is cautiously hammered. This is repeated until the whole is obtained in a compact state.[†]"

[*] Nicholson's Journal, vol. ix. p. 65.
[†] Philosophical Magazine, vol. xxi. p. 175.

of gold in proportion as it is deprived of iron : so that it is considered as a truly peculiar metal.

This metal is capable of being alloyed with most of the known metals.

Scheffer first affirmed that arsenic rendered it fusible.

Messrs. Achard and De Morveau have availed themselves of this property to fuse it, and compose vessels.

Platina easily unites with bismuth. The result is eager, very brittle, difficultly cupelled ; and the result is a mass which has little ductility.

Antimony likewise facilitates the fusion of platina. The alloy is brittle ; part of the antimony may be disengaged by fire ; but a sufficient quantity remains in combination to deprive the platina of its weight and ductility.

Zinc renders this metal more fusible. The alloy is very hard ; great part of the zinc may be volatilized by fire ; but the platina always retains a small quantity.

This metal unites easily with tin. This alloy is very fusible, and flows clear; it is eager, and very brittle : but when the tin is in a large proportion, the alloy is ductile ; its grain is coarse, and it becomes yellow by exposure to the air.

Lead unites very well with platina. A stronger heat is required to fuse this than the foregoing alloy. It is not ductile ; is no longer capable of being absorbed by the cupel, the absorption only taking place when the lead is in excess ; but the platina remains always united to a considerable portion of the metal. Nevertheless Messrs. Macquer and Baumé cupelled one ounce of platina and twenty ounces of lead, by exposing this alloy, for fifty hours, in the hottest part of the porcelain furnace at Seves. Mr. De Morveau had the same result in Mr. Macquer's windfurnace : the operation lasted between eleven and twelve hours. Mr. Baumé observed that the platina obtained by this process possesses the power of being forged, and soldered completely, without the assistance of any other metal, which renders it a most valuable acquisition in the arts.

Dr. Lewis could not unite forged iron with platina ; but having melted crude iron with this metal, there resulted an alloy so hard that the file could not touch it ; it was ductile in the cold, but broke short when hot.

Copper and platina alloyed together form a very hard metal, which is ductile, while the copper predominates in the proportion of three or four to one : it takes a fine polish, and was not tarnished during the space of ten years.

Platina, alloyed with silver, deprives it of its ductility, increases its hardness, and tarnishes its colour. These two metals may be separated by fusion and repose. Lewis observed that the silver which is fused with platina is thrown up against the sides of the crucible with a kind of explosion : this phenomenon appears to be owing to the silver, as Mr. Darcet found it break porcelain balls in which it was inclosed, and out of which it was projected by the action of the fire.

Gold is not capable of being alloyed with platina but by the most violent heat : the colour of the gold is prodigiously altered, and the alloy possesses considerable ductility.

We know enough of the properties of this metal to presume that it will prove of the greatest use in the arts. Its almost absolute infusibility, and its unchangeableness, render it of extreme value to form chemical vessels, such as crucibles, and the like. The property of soldering or welding without mixture, renders it preferable to gold or silver.

Its density and opacity render it likewise of great value for the construction of optical instruments ; and the abbé Rochon has constructed a mirror whose effect greatly surpasses that of the mirrors before made of steel and other metals. This metal unites two qualities never before found in one and the same substance. Like other metallic mirrors, it reflects but one single image; at the same time that it is as unchangeable as the mirrors of glass.

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CHAPTER XVI.

Concerning Tungsten and Wolfram.

WE are acquainted with two minerals which may be distinguished by the generic title of Tungsten: the one white, and known by the name of Tungsten, or the Heavy Stone of the Swedes; the other known by the name of Wolfram by mineralogists. We shall examine each separately.

ARTICLE I.

Concerning Tungsten.

Tungsten is a substance of an opaque white colour, very heavy, and of a moderate degree of hardness: its crystals are octahedrons. Its specific gravity is 6,0665, according to Brisson; from 4,99 to 5,8, according to Kirwan. The cubic foot weighs 424 livres 10 ounces 3 gross 60 grains.

When exposed without addition to the flame of the blow-pipe, it decrepitates without melting. With soda it is divided with a slight effervescence; is partly soluble in the native phosphate, or microcosmic salt; and affords a fine blue colour without the least appearance of red in the refracted light, as happens with cobalt. It is soluble in borax without effervescence.

Bergmann affirms that by pouring the muriatic acid upon pulverized tungsten the powder immediately assumes a fine bright yellow colour. To this character Scheele adds that of becoming blueish when boiled in the sulphuric acid.

This substance has a sparry appearance, and was long confounded with the white tin ore. It is found at Bitsberg, at Riddharhittan, at Marienburg, at Altemburg in Saxony, and at Saubergnear Ehrenfriedersdorff.

Mr. Raspe, in Crell's Annals for June 1785, gave an account of two mines of tungsten in the province of Cornwall, from which thousands of tons might be extracted. This philosopher obtained the metal in the proportion of about thirty-six livres the quintal. He adds that this metal contains little iron; that it is very fixed, and refractory in the fire; and that it acts on glass like the hardest steel.

Cronstedt arranges the tungsten among iron ores; and defines it to be *ferrum calciforme terrâ quâdam incognitâ intimè mixtum.*

Scheele has affirmed that it is a salt resulting from the combination of calcareous earth with a peculiar acid; which acid, combined with lime-water, regenerates tungsten.

Bergmann considers the acid earth of tungsten as a metallic acid.

Several processes are at present known for extracting the acid of tungsten.

1. Any desired quantity of this mineral is to be pulverized, and fused with four times its weight of carbonate of potash, and poured out upon a plate of metal. The mass is then to be dissolved in twelve parts of boiling water. A white powder separates during the solution, and falls to the bottom of the vessel. This precipitate is a true carbonate of lime, mixed with a small quantity of quartz, and a portion of undecomposed tungsten. The carbonate of lime may be taken up from the precipitate by nitric acid; and the remaining tungsten being mixed with the former proportion of carbonate of potash, is to be fused, dissolved, and by a repetition of these operations will at length be totally decomposed. The water in which the fused masses were washed, holds in solution a salt formed by the tungstic acid and the alkali made use of. If this solution be saturated with nitric acid, it seizes

the alkali ; the solution becomes thick ; and a white pow-
der falls down, which is the tungstic acid.

2. Scheele, the author of this first process, proposes a
second, which consists in digesting three parts of weak
nitric acid upon one of pulverized tungsten.   This pow-
der becomes yellow ; the fluid is then decanted, and two
parts of ammoniac are poured upon the yellow powder.
The powder then becomes white ; and in this way the re-
peated actions of the acid and the alkali are applied until
the tungsten is dissolved.   Out of four scruples, treated
by Scheele in this manner, there were three grains of
insoluble matter, which was a true quartz.   By adding
the prussiate of potash to the nitric acid made use of, he
obtained two grains of Prussian blue ; potash precipitated
three of chalk ; and the ammoniac uniting to the nitric
acid, precipitated an acid powder, which is the true tung-
stic acid.

In this experiment the nitric acid seizes the lime,
and uncovers the tungstic acid, which is seized by the
alkali.

The muriatic acid may be substituted to advantage
instead of the nitric acid, and even gives it a yellow
colour.

Scheele and Bergmann considered this acid powder as
the true tungstic acid in a state of purity.   Messrs.
Delhuyars have asserted that this acid was mixed with
the acid made use of in obtaining it, and also with
the alkali ; they assert that the yellow powder which is
uncovered by the digestion of the nitric acid, is the true
acid oxide of tungsten without mixture.

The white powder which is obtained by decom-
posing the alkaline solution of tungsten by an acid,
is acid to the taste, reddens the tincture of turn-
sol, precipitates the sulphure of alkali of a green
colour, and is soluble in twenty parts of boiling
water.

Properties of the white powder obtained by decomposing the solution of the ore of tungsten by an acid.

1. An acid taste, reddening the tincture of turnsol.

2. Exposed to flame urged by the blow-pipe, it passes to a brown and black colour, without affording either fumes or signs of fusion.

3. It is soluble in twenty parts of boiling water.

4. It becomes yellow by boiling in the nitric and muriatic acids, and blueish in the sulphuric acid.

Properties of the yellow matter obtained by fire or by acids.

1. Insipid, reddening the tincture of turnsol.

2. Treated with the blow-pipe, it preserves its yellow colour in the external flame; but swells up, and becomes black, without fusing, in interior blue flame.

3. It is insoluble, but capable of becoming so divided as to pass through the filters.

4. The three mineral acids have no action upon it.

From this comparison it appears that the acid is purer in the yellow powder than in the white; and the saline combinations of these two substances have confirmed Messrs. Delhuyars in their opinion.

The yellow acid, combined with potash, either in the dry or humid way, forms a salt with excess of alkali. If a few drops of nitric acid be poured on this salt, a white precipitate is instantly formed, which is re-dissolved by agitation. When all the alkali is saturated, the solution is bitter; if more acid be poured in, the precipitate which falls down is no longer soluble. This precipitate, when well edulcorated, is exactly of the same nature as the white powder we have spoken of. The experiments of Messrs. Delhuyars, and of Mr. De Morveau, prove very clearly that this white powder contains the acid of tungsten, a portion of the potash with which it was before combined, and a small quantity of the precipitating acid.

It is therefore well proved that the yellow matter is the pure oxide, and the true tungstic acid. It is likewise very certain that this acid exists ready formed in the metal; and that its oxigene is afforded neither by the decomposition of another acid, nor the fixation of the oxigenous gas of the atmosphere; it appears to exist in the mineral, and to constitute a salt of many principles.

The pure tungstic acid dissolves ammoniac; but the result is always with excess of alkali. This solution af-

fords by evaporation small crystals, of a penetrating bitter taste, soluble in water, and then reddening blue paper. The alkali is easily separated; and these crystals return by calcination to the state of yellow powder, entirely similar to that which entered into its composition. If the calcination be made in closed vessels, the residue is of a deep blue colour; for the yellow colour does not appear unless the calcination be made in the open air.

The experiments of Mr. De Morveau permitted him to class the affinities of this acid in the following order, which is the same as that of the arsenical acid, lime, barytes, magnesia, potash, soda, ammoniac, alumine, metallic substances.

ARTICLE II.

Concerning Wolfram.

Wolfram is of a blackish brown colour, sometimes affecting the form of an hexahedral compressed prism, terminated in a dihedral summit. These surfaces are frequently striated longitudinally. Its fracture is lamellated, foliated, and the leaves are flat, though rather confused. Externally it resembles schorl; but is not fusible, and is incomparably heavier.

Some mineralogists have taken it for an arsenical ore of tin; others for manganese, mixed with tin and iron. Messrs. Delhuyars, who made a strict analysis of it, found it to contain manganese 22, oxide $13\frac{1}{2}$, quartzose powder 2, yellow powder or tungstic acid 65.

The wolfram which was analyzed by these chemists, came from the tin mines of Zinnwalde, on the frontiers of Saxony and Bohemia. Its specific gravity was 6,835.

Wolfram does not melt by the blow-pipe without addition, its angles being scarcely rounded. With the native phosphate, or microcosmic salt, it melts with effervescence, and affords a glass of an hyacinth colour.

It effervesces with borax, and forms a greenish yellow glass in the blue flame. This glass becomes red in the external flame.

Pulverized wolfram upon which the muriatic acid is boiled, assumes a yellow colour like tungsten.

Messrs. Delhuyars fused in a crucible two gross of pulverized wolfram, and four gross of potash. The fused mixture being poured out on a plate of copper, a black matter remained in the crucible; which, when well edul-corated, weighed thirty-seven grains, and was found to be a mixture of iron and manganese.

The mass which had been poured out was dissolved in water, filtered, and saturated with nitric acid. It afforded a white precipitate, absolutely similar to that obtained from tungsten by a similar process.

The process of Scheele, by the humid way, succeeds equally well, and even appeared to Messrs. Delhuyars to be more advantageous. They prefer the disengagement, by mere heat, of the ammoniac which holds the tungstic acid in solution. One hundred grains of wolfram, treated with the muriatic acid and ammoniac, afforded them six-ty-five grains of a yellow powder, which is the pure acid.

This yellow acid powder unites with most of the me-tals. Messrs. Delhuyars relate the following facts:

1. One hundred grains of gold leaf, and fifty grains of the yellow matter, urged by a violent heat for three quar-ters of an hour, in a crucible lined with charcoal, afforded a yellow button, which crumbled in pieces between the fingers, and internally exhibited grains of gold, with others of a grey colour. This button weighed one hundred and thirty-nine grains, and was cupelled with lead, though with difficulty.

2. Similar proportions of platina and the yellow matter, treated in the same way (for an hour and a quarter,) af-forded a friable button, in which grains of platina were distinguishable, of a whiter colour than ordinary. It weighed one hundred and forty grains.

3. With silver, the yellow matter formed a button of a white greyish colour, rather spongy, which extended it-self easily by a few strokes of the hammer; but on con-tinuing them it split in pieces. This button weighed one hundred and forty-two grains, and the mixture was per-fect.

4. With copper, it afforded a button of a coppery red colour, inclining to grey, which was spongy, and considerably ductile. It weighed one hundred and thirty-three grains.

5. With crude or cast iron, of a white quality, it afforded a perfect button, whose fracture was compact, and of a greyish white colour. It was hard, brittle, and weighed one hundred and thirty-seven grains.

6. With lead, it afforded a button of an obscure grey colour, with very little brilliancy, spongy, very ductile, and splitting into leaves when hammered. It weighed one hundred and twenty-seven grains.

7. The button formed with tin was of a lighter grey than the preceding, very spongy, somewhat ductile, and weighed one hundred and thirty-eight grains.

8. The button of antimony was of a bright grey, rather spongy, brittle, and easily broken; it weighed one hundred and eight grains.

9. That of bismuth presented a fracture which, when seen in one direction, was of a grey colour, and metallic lustre; but in another direction it appeared like an earth without any lustre: but in both cases an infinity of pores were seen over the whole mass. It weighed sixty-eight grains.

10. The button formed with zinc was of a black greyish colour, and an earthy aspect, very spongy, and brittle: it weighed forty-two grains.

11. With common manganese it afforded a button of a blueish grey colour, and earthy aspect. Its internal part, examined with a lens, resembled an impure scoria of iron; it weighed one hundred and seven grains.*

These experiments confirm the suspicion of the celebrated Bergmann; who, from the specific gravity of this substance, and its property of colouring the native phosphate and borate of soda, concluded that it was of a metallic nature.

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* In Cullen's Translation of the Chemical Analysis of Wolfram, printed in London in 1785, I find the word *brown* in every place where M. Chaptal has used the word *grise*, or *grey*. Not having the original, I cannot speak with certainty; but from circumstances conclude this last to be right.   T.

The change of colour which accompanies its reduction, its increase of weight by calcination, its metallic aspect, and its uniting with other metals, are incontestable proofs of its metallic nature. The yellow matter must therefore be considered as a metallic oxide; and the button obtained by exposing this oxide to a strong fire, with powder of charcoal, is a true metal.

Messrs. Delhuyars having put one hundred grains of the yellow matter into a lined crucible well closed, and exposed it to a strong heat for an hour and a half, found upon breaking the crucible, when cold, a button which was reduced to powder between the fingers: its colour was grey. On examining it with the magnifier, an as- semblage of metallic globules were seen, among which some were of the bigness of a pin's head, and when broken exhibited a metallic fracture resembling steel. It weighed sixty grains, and of course there was a diminu- tion of forty. Its specific gravity was 17,6. Having calcined a part of it, it became yellow with $\frac{24}{100}$ increase of weight. The nitric and the nitro-muriatic acid changed it into a yellow powder. The sulphuric and muriatic acids diminished its weight, and their solution let fall Prussian blue. The metallic grains always remained af- ter the action of these acids. This metal shews various properties, which distinguish it from all others known. 1. Its specific gravity is 17,6. 2. It forms peculiar glass with the several fluxes. 3. It is almost absolutely infusible, much less fusible than manganese. 4. Its oxide is of a yellow colour. 5. It forms peculiar alloys with the known metals. 6. It is insoluble in the sulphuric, muriatic, nitric, and nitro-muriatic acids; and these two last convert it into an oxide. 7. The oxide combines with alkalis. 3. The oxide is insoluble in the sulphuric, nitric and muri- atic acids, and assumes a blue colour with this last.

Wolfram ought to be considered as an ore, in which this metal is combined with iron and manganese, as Messrs. Delhuyars have proved.

CHAPTER XVII.

Concerning Molybdena.

TWO substances have long been confounded toge-
ther under the name of Black Lead Ore, Mineral
Lead, Plumbago, and Molybdena, which the more ac-
curate analysis of the celebrated Scheele has proved to be
of a very different nature.

Molybdena cannot be confounded with the mineral of
which black lead pencils are made, which is called Plum-
bago. The characteristic differences are sufficiently evi-
dent to leave no doubt on this subject.

Molybdena is composed of scaly particles, either large
or small, and slightly adherent to each other. It is soft
and fat to the touch, soils the fingers, and makes a trace
of an ash-grey colour. Its aspect is blueish, nearly re-
sembling that of lead. The mark it makes on paper has
an argentine brilliancy; whereas those of plumbago are
of a darker and less shining colour : its powder is blueish;
by calcination it emits a smell of sulphur, and leaves a
whitish earth. The nitric and the arsenical acids are the
only acids which attack it effectually; it is soluble in soda
with effervescence before the blow-pipe; it causes the ni-
trate of potash to detonate, and leaves a reddish residue;
when exposed to the flame of the blow-pipe in the spoon,
it emits a white fume.

Plumbago is less fat, less granulated, and composed of
small brilliant particles. It loses in the fire $\frac{98}{100}$ of its
weight, and the residue is an oxide of iron.

Molybdena has been found in Iceland, in Sweden, in
Saxony, in Spain, in France, &c. that of Iceland is found
in plates, in a red feld spar mixed with quartz.

Mr. Hassenfratz gave Mr. Pelletier samples of molyb-
dena similar to those of Iceland, which he had collected
in the mine named Grande Montagne de Chateau Lam-
bert, near Tillot, where a copper mine was formerly
wrought.

William Bowles appears to have found molybdena near the village of Real de Monasterio: it is in banks of grit stone, sometimes mixed with granite.

The molybdena of Nordberg in Sweden is accompanied with iron that obeys the magnet.

The molybdena of Altemberg in Saxony nearly resembles that of Nordberg.*

Mr. Pelletier analyzed all these species; and his work may be consulted in the Journal de Physique for 1785; but the experiments we shall here relate were made with that of Altemberg.

Molybdena, exposed to heat on a test, becomes covered, after the space of an hour, with a white oxide; which, when collected by a process similar to that used with the sublimed oxide of antimony, has all the appearances of this last substance. The whole of the molybdena may by this means be converted into oxide. We are indebted to Mr. Pelletier for this fine experiment, which had escaped Scheele.

Molybdena is indestructible in close vessels, and prodigiously refractory, according to the experiment of Mr. Pelletier, made with balls of porcelain exposed to the most intense heat.

Molybdena treated with the black flux was not reduced, nor even deprived of its sulphur.

Molybdena fused with iron affords a button, which resembles cobalt: it unites likewise perfectly with copper; but when mixed with lead and tin, it renders them so refractory that the results are pulverulent and infusible alloys.

The oxide of molybdena obtained by calcination, or by the action of the nitric acid, is not reducible when treated with black flux, alkali, charcoal, or the other saline fluxes; nevertheless if the oxide of lead or copper be added, the metals which result are alloyed with a portion of molybdena, which may be separated.

* Molybdena is found in Chester county, Pennsylvania, mixed with iron and copper pyrites, and adhering to white quartz. Its specific gravity at 62° of Fahrenheit, is 4.648. It has also been discovered on granite, in the southern parts of the state of New-York.—*Am. Ed.*

The oxide of molybdena made into a paste with oil, dried by the fire, put into a lined crucible, and urged by a violent heat for two hours, afforded Mr. Pelletier a substance slightly agglutinated, which could be broken with the fingers. It was black, but perceptibly of a metallic aspect. When viewed with the magnifier, small round grains of a greyish metallic colour were seen, which are the metal of molybdena. It is prodigiously refractory : for the fire which Mr. Pelletier gave was stronger than that which Mr. Darcet used in the same forge to fuse platina and manganese.

1. Molybdena is calcinable, and passes to the state of a very white oxide. 2. It detonates with nitre, and the residue is an oxide of manganese mixed with alkali. 3. The nitric acid converts it into a white acid oxide. 4. The alkalis disengage hydrogenous gas from it in the dry way, and the residue is the oxide of manganese and alkali. 5. It alloys with the metals in different manners. Its alloys with iron, copper, and silver, are very friable. 6. When treated with sulphur, it regenerates the mineral molybdena.

According to Mr. Kirwan, the mineral of molybdena contains fifty-five pounds sulphur, and forty-five metal. The iron is accidental.

To reduce the mineral molybdena to powder, Scheele directs that it be triturated in a mortar with a small quantity of sulphate of potash. The powder is afterwards washed in hot water, to carry off the salt, and the molybdena remains pure.

This ore is a true pyrites, which, when treated with the blow-pipe, emits a white acid fume. But as this method affords only a small quantity of oxide, another method is used to obtain it. Thirty parts of nitric acid are distilled on one of powder of molybdena ; care being taken to use a large retort, and to pour the acid on at several times, having previously diluted it with one-fourth of water. The receiver being luted on, the distillation is performed on the sand-bath. When the fluid begins to boil, a considerable quantity of nitrous gas comes over.

The distillation being continued to dryness, there remains a powder, upon which an additional dose of nitric acid is poured; and this management is repeated until all the nitric acid has been used. At the end of the process there remains a residue as white as chalk, which is to be washed with water to carry off a small quantity of sulphuric acid, which is formed by the decomposition of the nitric acid upon the sulphur. After this edulcoration there remains six gross thirty-six grains of an acid powder, when the operation has been made with thirty ounces of nitric acid, and one ounce of molybdena. It is the molybdic acid.

The arsenical acid distilled from the mineral molybdena, likewise affords the molybdic acid.

It is evidently seen that its formation, like that of the arsenical acid, is owing only to the decomposition of the acid made use of, and the fixation of their oxigene on the metal employed.

This acid is white, and leaves a perceptibly acid and metallic taste on the tongue.

Its specific gravity compared with that of pure water is 3,460 : 1,000, according to Bergmann.

It undergoes no alteration in the air.

It does not rise in sublimation, but by the assistance of the air.

It colours the native phosphate of a beautiful green.

If it be distilled with three parts of sulphur, the mineral molybdena is regenerated. This acid is soluble in five hundred and seventy times its weight of water at a mean temperature. The solution is very acid; decomposes the solutions of soap; precipitates the sulphures of alkali. It becomes blue and consistent by cold.

The concentrated sulphuric acid dissolves a large quantity of it. The solution assumes a fine blue colour, and becomes thick by cooling. This colour disappears by heat, and returns again as the fluid cools.

The muriatic acid dissolves a considerable quantity by the assistance of ebullition. If the solution be distilled, it leaves a residue of an obscure blue colour. By an increase of heat, white sublimate rises mixed with a little blue; the fuming muriatic acid passes over into the re-

ceiver.   This sublimate attracts humidity, and is nothing
but the molybdic acid volatilized by the muriatic.

This solution of the molybdic acid precipitates silver,
mercury, and lead, from their solutions in the nitric acid.
It likewise precipitates lead from its solution of the mu-
riate of lead, but not the other metals.

The molybdic acid takes barytes from the nitric and
muriatic acids.

In the dry way it decomposes the nitrate of potash, and
the muriate of soda ; and the acids pass over in the fum-
ing state.

It disengages·the carbonic acid from its combinations,
and unites with the alkalis.

It even partly decomposes the sulphate of potash by
the assistance of a strong heat.

It dissolves several metals, and assumes a blue colour
in proportion as it yields its oxigene to them.

The combinations of this acid with the alkalis are lit-
tle known.   Scheele however has observed, that fixed al-
kali renders this acid earth more soluble in water ; that
the alkali prevented the acid from rising ; that the mo-
lybdite of potash is precipitated by cooling in small gra-
nulated crystals.

The oxigene adheres but slightly to the molybdic base :
for this acid boiled with the semi-metals does not fail to
assume a blue colour.

Hydrogenous gas passed through it is sufficient to pro-
duce the blue colour.

Molybdena, as Mr. Pelletier has observed, has great
resemblance in its chemical results to antimony ; since,
like that semi-metal, it is capable of affording by calci-
nation an argentine oxide, capable of vitrification.*

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* PALLADIUM.

This metal is so called from Pallas, the name of the planet disco-
vered by Dr. Olbers.

Dr. Wollaston has given the following method of separating Pal-
ladium from Platina, in which metal it is always found.

To a solution of crude platina, whether rendered neutral by eva-
poration of redundant acid, or saturated by addition of potash, soda,
or ammoniac, by lime or magnesia, by mercury, by copper, or by
iron, and also whether the platina has or has not been precipitated
from the solution by sal ammoniac, it is merely necessary to add a

solution of prussiate of mercury, for the precipitation of the pal-
ladium. Generally for a few seconds, and sometimes for a few mi-
nutes, there will be no appearance of any precipitate ; but in a short
time the whole solution becomes slightly turbid, and a flocculent
precipitate is gradually formed, of a pale yellowish white colour.
This precipitate consists wholly of prussiate of palladium. and when
heated will be found to yield that metal in a pure state, amounting
to about four or five-tenths per cent. upon the quantity of ore dis-
solved.

The decomposition of muriate of palladium, by prussiate of mer-
cury, is not effected solely by the superior affinity of mercury for
the muriatic acid. but is assisted also by the greater affinity of prus-
sic acid for palladium ; for Dr. Wollaston has found, that prussiate
of palladium may be formed by boiling a precipitated oxide of pal-
ladium in a solution of prussiate of mercury.*

Palladium is soluble in the nitric acid, and makes a dark red so-
lution. Green vitriol precipitates it in the state of a regulus from
this solution. If the solution is evaporated. a red oxide is obtained,
that is soluble in the muriatic and some other acids. It may be
precipitated by all the metals, except gold, platina. and silver. Its
specific gravity by hammering is 11.3 ; but by flatting as much as
11.8. Mr. Chenevix informs us, he found it to vary considerably
in different specimens. Some pieces of the substance were as low
as 10.972, while others gave 11.482.†

The greatest heat of a blacksmith's fire will hardly melt it, but
if it is touched while red hot, with a piece of sulphur, it runs as
easily as zinc.

A small portion of it destroys the colour of a large quantity of
gold. It is a worse conductor of heat than silver or copper. It ex-
pands by heat more than platina, but less than steel.

IRIDIUM.

This metal, so called from the variety of colours it gives, when
dissolving in marine acid, accompanies the ore of platina, but passed
unobserved for a long time, from its great resemblance to the grains
of platina, and on that account is scarcely to be distinguished or se-
parated from them, excepting by solution of the platina ; for the
grains are wholly insoluble in nitro-muriatic acid.

When tried by the file, they are harder than the grains of platina,
and possess no malleability. In the fracture they appear to consist
of lamina, possessing a peculiar lustre.

Their most remarkable quality is their great specific gravity,
which is 19.5, while that of the crude grains of platina does not ex-
ceed 17.7.

Dr. Wollaston considers them to be an ore, consisting entirely of
the metals, that were found by Tennant, in the black powder, which

* Phil. Trans. of the Royal Society of London for 1805, p. 326.
† Phil. Trans. of the Royal Society of London for 1803, page 291.

is extricated by solution from the grains of platina, and which he has called Iridium and Osmium.*

The method Mr. Tennant used for dissolving this black powder, was similar to that employed by Vauquelin, the alternate action of caustic alkali and an acid. He put a quantity of the powder into a crucible of silver, with a large proportion of pure dry soda, and kept it in a red heat for some time

The alkali being then dissolved in water, had acquired a deep orange, or brownish yellow colour, but much of the powder remained undissolved. This powder digested in marine acid, gave a dark blue solution, which afterwards became of a dusky olive green, and finally by continuing the heat, of a deep red colour. Part of the powder being yet undissolved by the marine acid, was heated as before with alkali; and by the alternate action of the alkali and acid, the whole appeared capable of solution.

In order to obtain the compound of iridium and the marine acid in a pure state, Mr Tennant tried to make it crystallize, by slow evaporation, and succeeded. The iridium may be obtained perfectly pure, merely by exposing these crystals to heat, which expels the oxigene and the muriatic acid. It appears of a white colour, and is infusible. It will not combine with sulphur and arsenic. Lead easily unites with it; but is separated by cupellation, leaving the iridium upon the cupel, as a coarse black powder. Copper forms with it a very malleable alloy, which after cupellation, with the addition of lead, left a small proportion of the iridium, but much less than in the former case. Silver may be united with it, and the compound remains perfectly malleable. Gold alloyed with iridium, is not freed from it by cupellation, nor by quartation with silver. The compound was malleable, and did not differ much in colour from gold, though the proportion of alloy was very considerable. If the gold or silver is dissolved, the iridium is left in the form of a black powder.*

OSMIUM.

This metal has been examined by Vauquelin, Descotil, Fourcroy, and Tennant. The brown yellow alkaline solution, mentioned under the head of Iridium, contains it. When this solution is first formed, by adding water to the dry alkaline mass in the crucible, a pungent and peculiar smell is immediately perceived. This smell arises from the extrication of a very volatile metallic oxide, and as this smell is one of its most distinguishing characters, it has been called Osmium.

The oxide may be expelled from the alkali by any acid, and obtained in solution with water by distillation. The sulphuric acid, being the least volatile, is the most proper for this purpose; but as, even of this acid, a little is liable to pass over, a second slow distillation is required, to obtain the oxide perfectly free from it. The solution procured in this manner is without colour, has a sweetish taste, and a strong smell. Paper stained blue by violets, was not

* Phil. Trans. of the Royal Society of London for 1805, p. 317.
† Phil. Trans. of the Royal Society of London for 1804, page 411.

changed by it to red ; but by being exposed to the vapour of it in a phial, the paper lost much of its blue colour, and inclined to grey. Another mode by which the oxide of osmium may be obtained in small quantity, but in a more concentrated state, is by distilling with nitre the original black powder procured from platina

With a degree of heat hardly red, there sublimes into the neck of the retort a fluid apparently oily, but which on cooling concretes into a solid, colourless semi-transparent mass.   The oxide in this concentrated state, stains the skin of a dark colour, which cannot be effaced.   The most striking test of the oxide of osmium, is an infusion of galls, which presently produces a purple colour, becoming soon after of a deep vivid blue.   The solution of the oxide of osmium with pure ammoniac, becomes somewhat yellow, and slightly so with carbonate of soda.   It is not affected by magnesia, nor by chalk ; but with lime a solution is formed, of a bright yellow colour.   The solution of lime gives with galls a deep red precipitate, which becomes blue by acids.   It produces no effect on a solution of platina or gold ; but precipitates lead of a yellowish brown, mercury of a white, and muriate of tin of a brown colour.

The oxide of osmium becomes of a dark colour with alkohol, and after some time separates in the form of black films, leaving the alkohol without colour.   The same effect is produced by ether, and much sooner.

This oxide appears to part with its oxigene to all the metals, except gold and platina.   Silver being kept in a solution of it for some time, acquires a black colour ; but does not entirely deprive it of smell.   Copper, tin, zinc, and phosphorus, quickly produce a black or grey powder, and deprive the solution of all smell, and of the power of turning galls of a blue colour.   This black powder, which consists of the osmium in a metallic state, and the oxide of the metal employed to precipitate it, may be dissolved in nitro-muriatic acid, and then becomes blue with infusion of galls.

If the pure oxide of osmium, dissolved in water, is shaken with mercury, it very soon loses its smell ; and the metal, combining with the mercury, forms a perfect amalgam.   Much of the mercury may be separated by squeezing it through leather, which retains the amalgam of a firmer consistence.   The remaining mercury being distilled off, a powder is left, of a dark grey or blue colour, which is the osmium in its pure state.   By exposing it to heat with access of air, it evaporates with the usual smell ; but if the oxidation is carefully prevented, it does not seem in any degree volatile.   Heated with copper and gold, it melted with each of these metals, forming alloys which were quite malleable.

The pure metal does not seem to be acted on by acids.*

RHODIUM.

This metal is so called, from the rose colour of a dilute solution of the salts containing it.

* Phil. Trans. of the Royal Society of London for 1804, page 411.

As platina generally has small particles of gold and some mercury mixed with it, the metal was freed mechanically from all visible impurities, and exposed to a red heat by Dr. Wollaston, in order to expel the mercury. It was then digested in nitro-muriatic acid, until the gold was dissolved, and other impurities that might be contained in the platina.

Nearly $2\frac{1}{2}$ ounces of the ore prepared in this manner, were dissolved in nitro muriatic acid, (diluted for the purpose of leaving as much as possible of a powder. which has the property of shining behind) and the whole was suffered to remain in a sand heat till completely saturated.

As much as corresponded to 1000 grains of the prepared ore, was precipitated by a solution of sal ammoniac, and yielded 815 of pure platina.

The residual liquor was precipitated by zinc, and produced between 40 and 50 grains of black powder, which was exposed to the action of dilute nitric acid, with a low degree of heat to extract copper and lead, and the remainder well washed in dilute nitro-muriatic acid, which took up all but $4\frac{1}{2}$ grains.

Twenty grains of common salt were added to the solution, and when the whole had been evaporated to dryness with a gentle heat, and washed with alkohol until it came off nearly colourless, the soda muriates of palladium and platina were carried off, and that of rhodium left free.

This salt of rhodium was dissolved in water and crystallized, the crystals a second time dissolved ; then divided, and one part precipitated by a piece of zinc ; the other part tried with a solution of sal ammoniac, prussiate of potash, hydro-sulphuret of ammoniac, and carbonated alkalis, gave no precipitate : but when a solution of platina was added, a precipitate of a yellow colour was immediately thrown down ; which proves that the metal contained in the salt is neither platina, nor the colouring matter of its red precipitate.

Pure alkali. likewise, threw down from it a yellow precipitate, soluble by excess of alkali, and by all the acids tried.

The solution of this oxide in marine acid did not crystallize, did not stain silver, left a metallic film on mercury, which did not amalgamate. and was precipitated by copper and other metals.

The portion of the rhodium precipitated by zinc from what remained after the washing with alkohol before mentioned, appeared in a black powder weighing two grains ; exposed to heat with borax, it acquired a white metallic lustre, but did not fuse. With arsenic and with sulphur. like platina, it became fusible. These substances may be driven off from it by heat, but it does not then become malleable.

It unites with all the metals tried, except mercury. with six parts of gold, one of rhodium may be united. so as no wise to differ in colour from pure gold. It is however more difficult of fusion : the effect of platina, on the contrary. is to destroy the colour of gold so much that one fifth of platina whitens the whole.

In an alloy of silver or gold, exposed either to nitric or nitro-muriatic acid, the rhodium remained untouched. But one part of rho-

dium to three of bismuth, copper or lead, dissolved completely in a mixture of two parts muriatic acid, with one of nitric. The specific gravity of rhodium exceeded 11.

URANIUM.

We are indebted to Klaproth for the discovery of this metal. It is found combined with sulphur, iron, lead, and silecious earth The ores of uranium are of a black colour, inclining to a dark iron grey, they are of a close texture, and come from the mines of Saxony.

This metal may be obtained in the following manner. The ore is to be exposed to heat to free it as much as possible from sulphur. It is then digested in nitric acid, which dissolves all metallic matter it contains, while part of the sulphur remains undissolved, and part of it is dissipated in the form of sulphurated hydrogen gas. This solution must be precipitated by a carbonated alkali. The precipitate. if pure, will be of a lemon yellow colour. This yellow carbonate must be made into a paste with oil, and exposed to a violent heat, bedded in a crucible, containing and lined with charcoal.

Uranium is obtained in small conglutinated metallic grains, forming a porous and spungy mass. Its specific gravity is 6.440. Its colour is a deep grey on the outside, in the inside it is of a pale brown colour.

It is more difficult of fusion than manganese.

It is soluble in sulphuric, nitric, and muriatic acids.

It combines with sulphur and phosphorus, and alloys with mercury. It decomposes the nitric acid, and becomes converted into a yellow oxide.

TELLURIUM.

This metal, called Sylvanite by Kirwan, is found in the mine of Mariahilf, in the mountains of Fatzbay, near Zalethna in Transylvania.

It is of a bluish white colour, laminated texture, and possesses considerable brilliancy. It is extremely brittle and friable. Its specific gravity is 6.115. It melts in a low degree of heat. It is next to mercury and arsenic, the most volatile of all the metals. Heated with the blow pipe on charcoal, it burns with a brilliant blue flame, greenish at the edges, and rises in grey whitish fumes. It combines with sulphur and forms a grey radiated sulphuret. It may be amalgamated with mercury.

Klaproth obtained this metal, by making the oxide of tellurium into a paste, with a few drops of linseed oil, and then putting it into a small glass retort or crucible, and exposing it to heat.

As the oil becomes decomposed, brilliant and metallic drops appear on the upper part of the vessel, which continually increase until the oxide is revived.

CHROMUM.

This metal is always found in the state of an oxide, and was dis-covered by the celebrated Vauquelin

He procured it from an ore, called the Red Lead Ore of Siberia, or Chromate of Lead, which is a combination of the chromic acid and lead.

Chromum is obtained in small agglutinated masses of a white co-lour, inclining to yellow; it is hard, brittle and refractory, and cry-stallizes in needles. Heated by the blow-pipe with borax, it does not melt; but a part after being oxidated. is dissolved in this salt, and communicates to it a beautiful green colour. The nitric acid converts it into an oxide. It is unalterable by potash, soda, and am-moniac.

Its other properties have not been examined.

TITANIUM.

A black sand is found in the valley of Menachan, in Cornwall, which is composed of iron and the oxide of titanium. This oxide may be revived by mixing one part of it with six of potash, and exposing the whole to a high degree of heat; the mass when cold is to be dissolved in water. A white precipitate will take place, which is the carbonate of titanium. This carbonate is to be made into a paste with a small quantity of oil, and the mixture put into a cruci-ble, filled with charcoal powder, and a little aluminous earth. The whole is then to be exposed for a few hours to a strong heat. The metal will be found in a black puffed up substance, possessing a me-tallic appearance.

Titanium is of an orange red colour, very brittle and refractory. Its specific gravity is about 4.2. It is volatilized in an intense heat. It is one of the most infusible of the metals. It will not combine with sulphur. Nitric acid has little effect upon it.

The muriatic acid oxides it. Nitro-muriatic acid changes it into a white powder. Boiling sulphuric acid decomposes it. It is not attacked by the alkalis. It does not combine with silver, copper, lead, and arsenic. It unites with iron, and forms an alloy of a grey colour, interspersed with yellow coloured brilliant particles.

Titanium is also found in the United States.

Dr. Archibald Bruce, of New-York, is in possession of a speci-men, found on the North river. Its matrix is marble, of a white co-lour and fine grain.

Dr. Mitchell received a large specimen of this metallic oxide mixed with iron, from New-Jersey. The editor has analyzed this specimen, and found it to consist of half its weight of iron, com-bined with titanium, lime and alumine, and no silex.

COLUMBIUM.

Mr. Hatchett being engaged in arranging some minerals, in the British Museum, observed a specimen of an ore, which resembled the Siberian chromate of iron. It had been sent from Connecticut, to Sir Hans Sloane, by Mr. Winthrop.

This ore is described, as being of a dark brown grey externally, and more inclining to an iron grey internally, the longitudinal fracture is lamellated, and the cross fracture has a fine grain. The colour of the streak or powder on paper, is a dark chocolate brown. Its particles are not attracted by the magnet. Its specific gravity at 65° of Fahrenheit is 5.918.

It is supposed that this ore consists of iron combined with a new metallic acid, which constitutes more than three-fourths of the whole.

As Mr. Hatchett did not succeed in obtaining a metal from this acid, the Columbium ought not to be considered as a metallic substance, until this is effected.

We are informed in the Medical Repository that it has been ascertained, that the specimen of this metal was taken from a spring of water in the town of New-London. The fountain is near the house in which Governor Winthrop used to live, and is about three miles distant from the margin of salt water, at the head of the harbour.*

TANTALIUM.

Mr. Ekeberg, a Swedish chemist, discovered this metal in two minerals found in Sweden, which he has called Tantalite and Yttrotantalite. The first is an alloy of this metal with iron and manganese.

Tantalium is distinguished from all the other metals by being insoluble in the acids. Alkalis act upon it, and the solution is decomposable by the acids, added in excess. The product obtained is of a white colour, which it retains after being exposed to a high degree of heat. Its specific gravity is 6.500. It fuses with phosphate of soda and ammoniac, and with borax into a colourless glass.

Exposed with charcoal to intense heat, it agglutinates and acquires a metallic aspect. Its fracture is brilliant, and its colour greyish black.

CERIUM.

Two Swedish chemists, Messrs. D'Hesinger and Bergilius, submitted to chemical examination, a fossil found at Bastnaes in Sweden, and the result was the discovery of a new metallic oxide. The celebrated Klaproth operated upon the same mineral, and likewise

* Med. Rep, Hexade ii. vol, 2, p. 437.

procured an oxide of Cerium, but considered it as an earth, to which he gave the name of Cchroites.

The fossil occurs disseminated or massive : it is of a flesh-red colour, more or less deep, with sometimes a shade of yellow : it is semi-transparent : its recent fracture has considerable lustre ; it strikes fire with steel with difficulty : is not attracted by the magnet: its specific gravity is 4.7 to 4.9. It does not melt in a strong heat, but loses five or six per cent. of its weight, becomes friable and acquires a bright yellow colour. With borax it forms a globule, greenish while hot, but colourless when cold.

One hundred parts of it yielded the Swedish chemists,

     50 of oxide of cerium,
     20 of iron,
     23 silex, and
      5.5 carbonate of lime.

According to Vauquelin's analysis of the same mineral, the proportions are,

Oxide of cerium,	63
Silex,	17.5
Oxide of iron,	2
Lime,	3 to 4
Water,	12

In order to obtain pure oxide of cerium, the mineral must be dissolved in aqua regia. The clear solution must be saturated with an alkali, and precipitated by tartrite of potash. The precipitate well washed, calcined and digested in the acetous acid, is the oxide of cerium.

After Vauquelin had made many attempts to reduce this oxide, he obtained a few metallic grains, by exposing the tartrite of cerium to an intense heat with lampblack, oil and borax.

Cerium is insoluble in any unmixed acid, and is dissolved with great difficulty in aqua regia. Its oxide readily combines with the acids, and the properties of its salts have been determined.

The oxide is soluble in the sulphuric acid. the solution is colourless or of a light-red tinge, of a sweet taste, and affords white crystals by evaporation.

The nitric solution of cerium, has a sweet and sharp taste, and does not easily crystallize.

Muriatic acid slowly dissolves the oxide of cerium, and is of a faint greenish yellow colour.

The salts of cerium may be decomposed by the alkalis. If phosphorus is placed in a solution of muriate of cerium, it gradually throws down a white precipitate. Iron and zinc do not precipitate the solutions of cerium.—*Am. Ed.*

NICKOLINUM.

Dr. J. B Richter has discovered a new metal, to which he has given the name of Nickolinum. This metal exists in the cobalt ores of Saxony.

" I was chiefly surprised," says Dr. Richter, " that Nickel, after being purified from cobalt, iron and arsenic, and after that reduced without the addition of a combustible body, never formed a mass, but was always found dispersed in small particles in a hard heavy mass, which had the appearance of the remains of vitrified copper.

" This hard matter had no metallic lustre, neither was it attracted by the magnet : its colour was of a blackish grey on the surface, with a small degree of brightness ; and in powder it was brown, greyish and greenish.

" Some weeks ago I endeavoured to reduce *per se* almost half a pound of oxide of nickel, which I had purified as well as possible by the liquid process, for the greatest part of a year, at a considerable expense : as this oxide was not of a lively green, I thought this was caused by the " extractive matter" which might be in the potash employed for the precipitation of the sulphate of nickel from the ammoniacal preparation : it is true that this triple combination had not that beautiful grass-green colour which it commonly had ; but I thought this might be caused by the substitution of the potash to the ammonia mixed with the copper, which could not be separated but by the reduction *per se.*

" From these ideas, I hoped to have at least four ounces of perfectly pure nickel, but was disagreeably surprised by finding in the crucibles, which were deformed in the usual manner and perforated by the vitrified copper, a rough mass with the appearance I have before mentioned, and which contained only a morsel of about two and a half drams, and consequently only five drams of pure nickel in the two crucibles. I reduced to powder in an iron mortar the remaining mass (which could not be properly called scoriæ), and separated from it, by the sieve and the magnet, the particles of nickel which it might contain, which produced near two and a half drams more ; and that nothing might be lost, I treated the powder with nitric acid, which attacked it vigorously at the first, and gave a solution of nickel, but after that did not act on it in the least, so that the powder was but little diminished in weight : in exposing this matter to reduction *per se*, it produced no regulus, but merely agglutinated its parts.

" Having again pulverised the mass, which weighed almost $4\frac{1}{2}$ ounces, I mixed with it one ounce of charcoal in powder, and exposed it to the fire of a porcelain furnace during eighteen hours, in a crucible closed with a luted cover, in a part of the furnace which seemed to me to have most heat. After having broken the crucible, which was in a sound state, I found, under the scoriæ of a deep blackish-brown colour, a well fused button of metal which weighed two ounces and three quarters : it was not at all connected with the adjoining parts of the scoria, and had at its inferior part a particular

shape, which was caused by cavities which were not produced by the
crucible

" This metal had the grey colour of steel, inclining a little to red :
it represented in its fracture a grain not very fine : it was rather
hard : could be extended a little under the hammer in a cold state :
heated to redness, it endured little the strokes of the hammer : it
was attracted by the magnet, but not so strongly as either iron or
nickel : it had many properties common to nickel, but it was distin-
guished from 'it entire y by others   As many of these properties
were such that those not well acquaint, d with nickel in its perfectly
pure state might take it for that metal, I have called it *Nickolinum*.

" The nickolinum was free from all the metals which are found in
the cobalt ores, except a little copper.

" The specific gravity of cast nickolinum, which enters more rea-
dily into fusion than nickel, is 8.55 ; and of forged nickolinum 8.60.
On putting it into nitric acid and heating it, it is attacked more
quickly than nickel.   I remember having observed an equally vio-
lent action of nitric acid on nickel reduced by charcoal, which I then
considered as pure, and which I dissolved in order to precipitate from
it by potash an oxide, which I might reduce *per se*.

" The solution of the nickolinum went on well ; being come to
the point of saturation, it had a blackish-green colour, and assumed
a gelatinous consistence.

" I employed my first care to separate from it a part of the iron
which I thought it contained, and left it to dry a little over a spirit
lamp ; the mass became continually of a deeper green, and in ap-
proaching to dryness it gave out much red vapours, and the residue
became of a blackish grey ; I added distilled water to it, which dis-
solved but little of it, and that which was dissolved was an insignifi-
cant quantity of nickel.

" I poured muriatic acid on the blackish powder well washed,
which gave a green solution, in disengaging a strong odour of oxi-
genated muriatic acid.

" The muriatic solution was, as well as the nitric solution, of a
deep blackish grass-green colour : being evaporated to dryness, it
produced a reddish mass, which became green in a moist air, and
which communicated the green colour to water in which it was dis-
solved.

" This dark-coloured oxide of nickolinum was insoluble in nitric
acid, and in sulphuric acid ; but if sugar or alcohol was added, the
solution took place with facility at the boiling point.

" The sulphate of nickolinum, being combined with water, is also
of a blackish green ; but it assumes a pale red colour on being de-
prived of the water.

" If carbonate of potash be added to the preceding solution of nick-
olinum, it occasions a precipitate of blue carbonate of nickolinum, in-
clining a little to grey and green, and of a pale tint : this combina-
tion is very light and soft, and dissolves in the acids with a strong ef-
fervescence.   I remember to have had, some years ago, this preci-
pitate of a bad colour, and not then to have examined it, considering
it as a mixture of iron, nickel and arsenic (which last continually

made itself noticed by its odour of garlic) : but at last I suspected its nature.

" If the solution of nickolinum is decomposed by caustic potash, it gives a precipitate which resembles in its colour carbonate of chrome —that is to say, it is of a deep greenish blue, which does not change when it is washed : being dried with a gentle heat, it assumes a pale colour, which becomes deeper when it is moistened with water.

" If any of the foregoing solutions of nickolinum is mixed with ammonia to excess, the liquor assumes a pomegranate red colour, and remains transparent ; which proves that it does not contain any iron, because that this latter is not soluble in ammonia. By candle-light this solution is with difficulty distinguished from that of perfectly pure nickel ; but by day light this latter is of an amethyst red colour, as I have elsewhere remarked.

" I shall now compare the principal properties in which nickolinum resembles altogether, or in part, nickel or cobalt, and those in which it is distinct from them.

" It resembles cobalt—

" 1. By its property of super-saturating itself with oxigene at the expense of the nitric acid, and thus forming a body which resembles the black oxide of manganese with regard to its solubility in the acids :—2. By its property of not being reducible but by the intervention of a combustible body.

" It differs from cobalt—

" 1. By the blackish-green colour of its solutions, even when they are entirely neutralized. It is known that the neutral solutions of cobalt in the sulphuric, nitric, and muriatic acids, are of a crimson-red colour ; and that the muriate of cobalt alone becomes of a greenish-blue on being deprived of its water : from whence it happens that an excess of acid produces this colour, because it combines with the water. With the muriate of nickolinum precisely the reverse takes place ; when mixed with water it is green (although of a less beautiful colour than the cobalt without water), and when deprived of its water it becomes reddish.—2. By the colour of its carbonate : that of cobalt is of a beautiful poppy blue, but the carbonate of nickolinum is a blueish green inclining to a pale grey.—3. By the colour of its oxide precipitated without carbonic acid : that of cobalt is of a deep blue, and changes on washing to a blackish brown ; but this oxide of nickolinum is of a greenish blue, and its colour does not change.

" Nickolinum resembles nickel—

" 1. By its strong magnetic quality ; although this is not so great as that of nickel.—2. By its malleability, which however is less than that of nickel.—3. By the deep green of its solutions ; although this colour is not so beautiful as that of the solutions of nickel —4. By the loss of this green colour when its neutral combinations are deprived of water.—5. By the colour of the acid solution with an excess of ammonia, which cannot be well perceived by candle-light.

" Nickolinum differs very distinctly from nickel—

" 1. Because it cannot be reduced without a combustible body added to it.—2. Because nitric acid attacks and oxidates it more easily.

Nickel is not near so readily acted on by the nitric acid if it is not mixed with the nickolinum, which almost always happens with the magnetic nickel which is considered to be in a state of purity, and which has not been reduced *per se* before my discovery.—3 It also differs from nickel by the property first mentioned of those in which it resembles cobalt.—4. By the colour of its combinations with the acids, when deprived of water : this colour in nickel is almost a buff *(chamois,)* and in nickolinum a reddish, except in the nitrate of nickolinum, which cannot be deprived of water without decomposing it.—5. By the colour of the precipitates, mentioned in the second and third articles concerning the properties wherein this new metal differs from cobalt, which are in those of nickel of a green colour, entirely different from those of nickolinum, which latter are of a much more agreeable green, especially those of the carbonate."

Whether this substance will retain its place among the metals, must be left to future investigation ; at present we have only the authority of Dr. Richter for inserting it.*—*Am. Ed.*

* Accum's Chemistry, vol. ii.

PART THE FOURTH.

CONCERNING VEGETABLE SUBSTANCES.

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INTRODUCTION.

THE mineral bodies upon which we have hitherto treated, possess no life, or vital principle, properly speaking; neither do they exhibit any phenomena dependant upon internal organization. The crystallization affected by substances of this kingdom, appears to be exceedingly different from the organization of living beings. It produces no advantage to the individual; and at most serves only to prove the great harmony of nature, which marks its several productions with constant and invariable forms. But the organization of vegetable and animal beings disposes those bodies in such a manner as is respectively the most proper to accomplish the two final purposes of nature; namely, the subsistence and reproduction of the individual.*

It cannot be denied that vegetables are endued with a principle of irritability, which develops in them both sensation and motion : the motion is so evident in certain plants, that it may be produced at pleasure, as in the sensitive plant, the stamina of the opuntia, &c. The plants which follow the course of the sun; those which in hothouses incline towards the apertures that admit the light;

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* For the development of these principles, see La These sur l'Analyse Vegetal supported at the schools of Montpellier by my scholar and friend, M. Riche.

other plants which contract and shut up by the puncture of an insect; those whose roots turn out of their direct or original course to plunge themselves into a favourable soil, or water—have not these a degree of sensation of touch which may be compared to the sensibility of animals? The difference of the secretions in various organs, supposes a difference in the irritability of each respective part.

The reproduction of vegetables is effected in the same manner as that of animals; and modern botanists have supported the comparison between these two functions in the most happy and conclusive manner.

Vegetables are nourished with air in the same manner as insects. This aliment is even of indispensable necessity, for without it the plant at last perishes: though the air which this order of beings requires, is neither of the same purity nor of the same kind.

The great difference which exists between vegetables and animals is, that the latter in general are capable of conveying themselves from place to place, in search of nourishment; whereas vegetables, being fixed in the same place, are obliged to take up in their own vicinity all such matters as are capable of nourishing them: and nature has provided them with leaves, to extract from the atmosphere the air and water of which they have need; while their roots extend to a distance in the earth, to take firm hold, as well as to receive other nutritive principles.

If we attend more minutely to the character of animals, we shall perceive that nature descends by imperceptible degrees from animals of the most complicated organization to vegetables; and we shall find it difficult to determine where one kingdom terminates, and the other begins. Chemical analysis is capable of marking the limits between these kingdoms in an imperfect manner. For a long time it was pretended that animal substances possessed the exclusive property of affording ammoniac, nor the volatile alkali; but it is at present well known that certain plants likewise afford it. We may in strictness consider a vegetable as a being that participates in the laws of animal life, but in a less degree than the animal itself.

The difference which has been established between the vegetable and the mineral kingdoms, is much more strik- ing. We may consider this last as a mass deprived of organization, and almost in an elementary state; receiv- ing no modifications or changes but by the impression of external objects; capable of entering into combinations; of changing its nature; and of re-appearing, or being re- produced with its original properties, at the pleasure of the chemist. The other kingdom, on the contrary, being endued with a particular life, which incessantly modifies the impression of external objects, decomposing them and changing their nature, exhibits to us a series of functions regular throughout, and almost all of them inexplicable; and when the chemist has succeeded in depriving these bodies of their organization, and separating their princi- ples, he finds it beyond his power to reproduce it by any re-union of the same principles.

In the mineral kingdom, we are justified in referring all the phenomena to the action of external bodies; and forces purely physical, or the simple laws of affinity, af- ford deductions sufficient to account for all its metamor- phoses. In the vegetable kingdom, on the contrary, we are compelled to acknowledge an internal force which per- forms every thing, governs all the processes, and subjects to its designs those agents which have an absolute empire over the mineral kingdom.

The mineral possesses no evident life, no period which may be considered as the term of its perfection; because its various states are always relative to the purposes to which we intend to apply it. It does not appear either to grow or to be reproduced: at most it changes its form, but never by any internal determination; this is always the mere physical effect of the action of external objects. In those cases wherein the mineral exhibits marks of in- crease or vegetation, it is by the successive application of similar materials worn and transported by the waters. In these apparent vegetations we perceive neither elaboration nor design: the law of affinities ever presides in these ar- rangements; and this law is the law of bodies void of life.

It is not therefore surprising that the chemical analysis should have made less progress in the vegetable than in

the mineral kingdom, for it becomes more difficult in pro-
portion as the functions are complicated : and in the ve-
getable kingdom the constituent parts are more numerous,
at the same time that they are less easily distinguished by
characteristic properties ; and the methods of analysis hi-
therto employed are all imperfect ; not to mention that
the proceedings of chemists have likewise been conducted
upon an erroneous principle.

All plants have hitherto been analyzed either by fire or
by menstruums. The first of these methods is very un-
certain ; for the action of fire decomposes combined bo-
dies, alters their principles, forms new bodies by the com-
bination of these separate elements ; and extracts nearly
the same principles from very different substances. Long
experience has shewn the imperfection of this method.
Messrs. Dodart, Bourdelin, Tournefourt, and Boulduc
have distilled more than fourteen hundred plants ; and it
was from the results of so extensive a work that Hom-
berg deduced sufficient reasons to conclude that this me-
thod is erroneous. As a proof of his assertion, he quotes
the analysis of cabbage and hemlock, which afforded the
same principles by distillation.

The method by menstruums is somewhat more accu-
rate, because it does not change the nature of the pro-
ducts : it has been even of greater advantage to medicine,
by affording methods of separating the medicinal princi-
ple from certain vegetables. It has also afforded its as-
sistance to extract other principles in all their purity,
which are useful in the arts, or for the purposes of life ;
and it has given us more instruction concerning the nature
of vegetable principles. But we cannot confine ourselves
to this single method in the analysis of plants ; and a con-
siderable share of genius is required in the chemist, to
vary his process according to the nature of the vegetable,
and the character of the principle he is desirous of ex-
tracting.

A reproach of considerable weight may be urged against
most of the chemists who have written upon the vegeta-
ble analysis ; it is, that they have followed no order in
their proceedings, nor attended to any regular distribu-
tion of the facts. They have confined themselves to in-
dicate processes for extracting such or such substances,

without connecting the whole with any system founded either on the methods of operating, on the nature of the products, or on the proceedings followed by nature in its own operations. I confess that, if a disquisition on the vegetable analysis were to be confined to the processes necessary to be known in extracting the several substances, the system of order and of method which I propose would be useless : but if it be an object to know the operation of nature, and to survey the vegetable kingdom like a philosopher, a naturalist, and a chemist, it is necessary to inspect the operations of nature herself among vegetables, and to follow as much as possible a plan which shall render us acquainted with the plant under all these points of view : that which I have adopted appears to me to answer that purpose.

We shall begin by exhibiting a cursory account of the vegetable structure, in order that we may become better acquainted with the connexion between its organization and the principles which we shall extract.

In the second place we shall attend to the development and increase of the vegetable. With this intention we shall shew the various principles which serve for its nourishment ; and we shall follow their alterations in the vegetable economy, as much as we are enabled to do. We shall therefore of consequence examine the influence of the air, the soil, the light, &c.

In the third place we shall examine the results of the work of organization upon elementary substances; and for that purpose we shall teach the method of distinguishing the several constituent principles of vegetables : taking care to proceed in this examination according to that method which nature herself points out.

Thus we shall begin with the analysis of such products as we can extract without destroying the organization of the plant, and which are exhibited in a naked state by that organization; such as the mucilage, the gums, the oils, the resins, the gum resins, &c. We shall in the next place analyze such principles as cannot be collected but by destroying the organization of the plant ; such as the fecula, the glutinous part, the sugar,

the acids, the alkalis, the neutral salts, the colouring principles, the extractive matter, iron, gold, manganese, sulphur, &c.

We shall likewise attend to the prolific humours of vegetables; that is to say, the examination of such sub-stances as though necessary to life, are urged outwards to answer certain functions: the pollen and honey are of this kind.

We shall afterwards examine the humours which eva-porate and escape by transpiration; such as oxigenous gas, the aqueous principle, the aroma, or odorant prin-ciple, &c.

And in the last place we shall shew the alterations to which vegetables are subjected after death.   In order to proceed with regularity in a question of such great im-portance, we successively examine the action of heat, of the air, and of water, upon the vegetable, whether they act separately or together.   This proceeding will render us acquainted with all the phenomena exhibited by vege-tables in their decomposition.

SECTION I.

Concerning the Structure of Vegetables.

EVERY vegetable exhibits in its structure—1. A fibrous and hard mechanism, which supports all the other organs, determines the direction, and gives the proper solidity to the several plants and their parts.   2. A cellular tissue, which accompanies all the vessels, en-velops all the fibres, contorts itself in a thousand ways, and every where forms coverings and a net-work, which connect all the parts, and establish an admirable commu-nication between them.   We shall describe the several parts of plants in a very concise manner, and shall con-fine ourselves to the explanation and description of such

organs as must necessarily be known with accuracy, be-
fore we can proceed to the analysis of plants.

ARTICLE I.

Concerning the Bark.

The bark is the external covering of plants : its pro-
longations or extensions cover all the parts which com-
pose the vegetable. We may distinguish three particu-
lar tunics, which may be separately detached and observ-
ed. The epidermis, the cellular tissue, and the cortical
coatings.

1. The epidermis is a thin membrane, formed of fibres
that cross each other in every direction : its texture is
sometimes so thin, that the direction of its fibres may be
seen by holding it against the light. This membrane is
easily detached from the bark when the plant is in a vi-
gorous state ; and when it is dried, the separation may
be effected by steeping it in water. When the epidermis
of a plant is destroyed, it grows again ; but is then more
strongly adherent to the rest of the bark, so as to form a
kind of cicatrice.

This epidermis appears to be intended by nature to mo-
dify the impressions of external objects upon the vegeta-
ble ; to furnish a great number of pores, which transmit
or throw off the excretory products of vegetation ; to pro-
tect the last or extreme ramification of the aërial or aque-
ous vessels, which extract out of the air such fluids as
are necessary for the increase of the vegetable; and to
cover the cellular organ, which contains the principal ves-
sels, and those glands in which the several fluids are di-
gested and elaborated.

2. The cellular coating forms the second part of the
bark. Its texture consists of vesicules and utricules, so
very numerous, and so close together, as to form a con-
tinued coating. It is among these glands that the work
of digestion appears to be performed ; and the product of
this elaboration is afterwards conveyed through the whole
vegetable, by vessels propagated through all its parts and

communications; even with the medullary substance or pith, by conduits that pass through the body of the tree, crossing the ligneous strata.   In this net-work it is that the colouring matter of vegetables is developed; the light which penetrates the epidermis concurs in enlivening the colour: here likewise it is that oils and resins are formed, by the decomposition of water and the carbonic acid: and lastly it is from this reticular substance that those various products of the organization are thrown off or excluded, which may be considered as the fæces of the vegetable digestion.

3. The coatings which lie between the external cover-ing and the wood or body of the vegetable, and may be called the cortical coatings, are formed of laminæ which themselves consist of the re-union of the common, pro-per, and air vessels of the plant.   The vessels are not extended lengthwise along the stem, but are curved in various directions; and leave openings or meshes between them, which are filled by the cellular matter itself. Nothing more is necessary to shew the organization, than to macerate these coatings in water, which destroys the cellular substances, and leaves the net-work uncovered.* The cortical coverings are easily detached from each other; and it is from their gross resemblance to the leaves of a book, that they have been called *liber*.   In propor-tion as these coatings approach the ligneous body, they become hard; and at length form the external softer part of the wood, which workmen call the sap.

The bark is the most essential part of the vegetable, by means of which the principal functions of life, such as nutrition, digestion, the secretions, &c. are performed. All plants and particularly those which are hollow within, and whose products are totally changed by covering them with a different bark, prove evidently that the digestive force eminently resides in this part.   The ligneous part is so far from being essential, that many plants are without it; such as the gramineous and the arundinaceous, and all plants that are hollow within.   Grasses, properly speak-

* This is most particularly seen in the *arbre à dentelle*, when the plant has been macerated in water.

ing, have only the cortical part. We often see plants internally rotten, but kept in vigour by the good state of their bark.

ARTICLE II.

Concerning the Ligneous Texture.

Beneath the bark there is a solid substance, which forms the trunk of trees, and appears to be usually composed of concentric layers. The interior coatings or rings are harder than the exterior; they are older, and of a more firm and close grain. The hardest of these form the wood, properly so called, while the softer external rings constitute the sap. We may consider wood as being formed of fibres, more or less longitudinal, connected together by a cellular tissue, interspersed with vesicles communicating with each other; which diminish gradually towards the centre, where they form the pith. The pith is found only in young branches or plants, and disappears in plants of a certain age.

The vesicular tissue bears a great analogy with the glandular and lymphatic vessels of the human body : in both, the conformation and uses are the same. In the early age of plants and animals, the organs have a considerable expansion, because the increase of the individual is very rapid at that period. But, as age advances, the vessels become obliterated in both kingdoms; and it is observed that, in the white woods and fungi which abound with the vesicular substance, the growth is also very rapid.

ARTICLE III.

Concerning the Vessels.

The various humours of vegetables are contained in cer-
tain appropriated vessels, in which they enjoy a degree of
motion that has been compared to the circulation in ani-
mals.   It differs from it, however; because these hu-
mours are not continually kept in equilibrio in the vessels
by an inherent force, but receive in a more evident man-
ner the impression of external agents.   Light and heat
are the two great causes which determine and modify the
motion of the fluids and vegetables.   These agents cause
the sap to rise into the various parts, where it is elabo-
rated in a manner correspondent to the functions of each;
but it is not observed that it returns : so that the acces-
sion or flux of the humours in vegetables is proved, but
the reflux does not appear to be perceptible.

Three kinds of vessels may be distinguished in vege-
tables : the common, or sap vessels ; the proper vessels ;
and the air vessels, or tracheæ.

1. The sap vessels convey the sap, or general humour,
from which all the others are derived.   This liquor may
be compared to the blood in animals.   These vessels
are reservoirs from which the several organs extract
the different juices, and elaborate them in a proper
manner.

The sap vessels chiefly occupy the middle of plants
and trees.   They rise perpendicularly, though with de-
flections sideways, so as to communicate with all the parts
of the vegetable.   They convey the sap into the utricu-
les ; whence it is taken by the proper vessels, in order
that it may be duly elaborated.

2. Each organ is likewise provided with peculiar vessels,
to separate the various juices, and to preserve them,
without suffering them to mix with the general mass
of humours.   Thus it is that we find in the same ve-

getable, and frequently in the same organ, juices of different natures, and greatly differing in colour and consistence.

The vessels, whether common or proper, are retained in their several directions by the ligneous fibres; they are every where surrounded by the cellular tissue; they open, and pour their fluid into glands, into the cellular tissue, and into the utricules, to answer the various functions.

The utricules are small vessels or repositories which contain the pith, and frequently the colouring matter. They form a kind of repository in which the nutritive juice of the plant is preserved, and whence it is taken on occasion; in the same manner as the collection of marrow is formed in the internal part of the bones, whence it is afterwards extracted when the animal is not sufficiently supplied with nutriment.

3. The tracheæ, or air vessels, appear to be the organs of respiration, or rather those which receive the air, and facilitate its absorption and decomposition. They are called tracheæ on account of the resemblance which is thought to exist between them and the respiratory organs of insects. In order to observe them, a branch of a tree is taken sufficiently young to break off short: after having cleared away the bark without touching the wood, the bough is broken by drawing the two extremities in opposite directions; the tracheæ are then seen in the form of small corkscrews, or vessels turned in a spiral direction. It is generally supposed that the large pores which are perceived in the transverse section of a plant, viewed in the microscope, are merely air vessels. It often happens that the sap is extravasated in the cavity of the tracheæ; and they appear incapable of serving any other purposes than that of conveying the air, at least for some time, unless a change takes place in the life of the plant.

ARTICLE IV.

Concerning the Glands.

Small protuberances are observed upon various parts of vegetables. These are glandular bodies whose form is prodigiously varied. It is more particularly upon this variation of form that Mr Guettard has grounded his seven species. They are almost always filled with a humour, whose colour and nature are singularly varied.

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SECTION II.

Concerning the Nutritive Principles of Vegetables.

IF plants were to perform no other act than that of pumping the nutritive principles they contain out of the earth; if they did not possess the faculty of digesting, assimilating them, and forming different products, according to their nature, and the diversity of their organs; it would follow as a consequence, that we ought to find in the earth all those principles which analysis exhibits to us in vegetables: a conclusion which is contradicted by the facts; for we shall hereafter prove that the production of vegetable earth is an effect of the organization of plants, and that it owes its formation to them instead of communicating principles ready formed to those individuals If it were true that plants did nothing but extract their component parts out of the earth, those plants which grow on the same soil would possess the same principles, or at least the analogy between them would be very great;

whereas we find plants of very different virtues and flav-
ours grow and flourish beside each other.　In addition to
this we may observe, that such plants as are raised in
pure water—the fat plants, which grow without being
fixed to the earth, provided they are placed in a moist at-
mosphere—the class of parasitical plants, which do not
partake of the properties of those which serve to support
them—prove that a vegetable does not derive its juices
from the earth, on account of its being earth; but that
it possesses an internal alterative and assimilating power,
which appropriates to each individual the aliment which
is suitable to it, at the same time that it disposes and com-
bines that aliment to form certain peculiar principles.
This digestive virtue will appear to be astonishingly per-
fect, when it is considered that the nutriment common
to all vegetables is very little varied, since we know only
of the water and air; and consequently that it possesses
the power of forming very different products with these
two simple principles.　But from this circumstance, that
the nutritive principles of plants are very simple, it must
be presumed that, in the various results of digestion, or
(which is the same thing) in the vegetable solids and
fluids, there must be the greatest analogy; and that the
differences are deducible from the proportion of the prin-
ciples, and their more or less perfect combination, rather
than from their variety.　With this intention we shall
carefully observe the transition from one principle to ano-
ther; and shall explain the art of reducing them all to
certain elementary or primitive substances, such as the
fibrous matter, mucilage, &c.

ARTICLE I.

Concerning Water, as a Nutritive Principle of Plants.

Every one knows that a plant cannot vegetate without
the assistance of water: but it is not so generally known
that this is the only aliment which the root draws from

the earth; and that a plant can live, and propagate itself, without any other assistance than the contact of water and air. It apppears to me, nevertheless, that the following experiments remove every doubt on this subject: Van Helmont planted a willow, weighing fifty pounds, in a certain quantity of earth covered with sheet lead: he watered it for five years with distilled water; and at the end of that time the tree weighed one hundred sixty-nine pounds three ounces, and the earth in which it had vegetated was found to have suffered a loss of no more than three ounces. Boyle repeated the same experiment upon a plant, which at the end of two years weighed fourteen pounds more, without the earth in which it had vegetated having lost any perceptible portion of its weight.

Messrs. Duhamel and Bonnett supported plants with moss, and fed them with mere water; they observed that the vegetation was of the most vigorous kind : and the naturalist of Geneva observes, that the flowers were more odoriferous, and the fruit of a high flavour. Care was taken to change the supports before they could suffer any alteration. Mr. Tillet has likewise raised plants, more especially of the gramineous kind, in a similar manner; with this difference only, that his supports were pounded glass, or quartz in powder. Hales has observed that a plant which weighed three pounds gained three ounces after a heavy dew. Do we not every day observe hyacinths and other bulbous plants, as well as gramineous plants, raised in saucers or bottles containing mere water.

All plants do not demand the same quantity of water; and nature has varied the organs of the several individuals conformably to the necessity of their being supplied with this food. Plants which transpire little, such as the mosses and the lichens, have no need of a considerable quantity of this fluid; and accordingly they are fixed upon dry rocks, and have scarcely any roots; but plants which require a larger quantity have roots which extend to a great distance, and absorb humidity throughout their whole surface.

The leaves of plants have likewise the property of absorbing water, and of extracting from the atmosphere the

same principle which the root draws from the earth. But plants which live in the water, and as it were swim in the element which serves them for food, have no need of roots; they receive the fluid at all their pores: and we accordingly find that the fucus, the ulva, &c. have no roots whatever. The purer the water, the more salutary it is to plants. Mr. Duhamel has drawn this consequence from a series of well-made experiments, by which he has proved that water impregnated with salts is fatal to vegetation. Hales caused them to absorb various fluids, by making incisions in their roots, and plunging them in spirits of wine, mercury, and various saline solutions; but he was convinced that these were all poisons to the vegetables. Besides, if these salts were favourable to the plants, they would be again found in the individual which had been watered with a solution of them; whereas Messrs. Thouvenel and Cornette have proved that these salts do not pass into the vegetable. We must, nevertheless, except the marine plants, because the sea salt of which they have need is decomposed in them; and produces a principle which appears necessary to their existence, since they languish without it.

Though it is proved that pure water is more proper for vegetation than water charged with salts, it must not on that account be concluded that water cannot be disposed in a more favourable manner to the development of vegetables, by charging it with the remains of vegetable and animal decomposition. If, for example, the water be loaded with principles disengaged by fermentation or putrefaction, the plant then receives juices already assimilated to its nature; and these prepared aliments must hasten its growth. Independent of those juices already formed, the nitrogene gas, which constitutes one of the nutritive principles of plants, and is abundantly afforded by the alteration of vegetables and animals, must facilitate their development. A plant supported by the remains of vegetables and animals is in the same situation as an animal fed on milk only; its organs have less difficulty in elaborating this drink than that which has not yet been animalized.

The dung which is mixed with earths, and decomposed, not only affords the alimentary principles we have spoken

of; but likewise favours the growth of the plant by that constant and steady heat which ulterior decomposition produces. Thus it is that Fabroni affirms his having observed the development of leaves and flowers, in that part of a tree only, which was in the vicinity of a heap of dung.

ARTICLE II.

Concerning Earth, and its Influence in Vegetation.

Although it be well proved that pure water is sufficient for the support of plants, we must not consider the earth as of no use. Its utility resembles that of the placenta, which of itself affords no support to the life of the infant, but which prepares and disposes the blood of the mother to become a suitable nourishment : or it resembles, and has a similar utility with the various reservoirs which nature has placed in the body of man, to preserve the several humours, and emit them upon occasion. The earth imbibes and retains water ; it is the reservoir destined by nature to preserve the elementary juice which the plant continually requires ; and to furnish that fluid in proportion to its wants, without exposing it to the equally fatal alternatives of being either inundated or dried up.

We even see that, in the young plant or embryo, nature has not chosen to entrust the labour of digestion to the still feeble germen. The seed is formed of a parenchyma, which imbibes water, elaborates it, and does not transmit it to the germen until it is reduced into juice or humour. By insensible gradations this seed is destroyed ; and the plant, become sufficiently strong, performs the work of digestion without assistance. In the same manner it is that we perceive the fœtus supported in the womb of its mother by the humours of the mother herself; but, when it has seen the light, it receives for nourishment a fluid less animalized, its organs are gradually strengthened, and at length become capable of digesting a stronger and less assimilated nourishment.

But on this very account, that the earth is destined to transmit to the plant that water which is to support it, the nature of the soil cannot be a matter of indifference, but

must be varied accordingly as the plant requires a more or less considerable quantity of water, accordingly as it demands more or less in a given time, and accordingly as its roots extend to a greater or less distance. It may therefore be immediately perceived that every kind of earth is not suitable for every plant, and consequently that a slip cannot be grafted indifferently upon every species.

A proper soil is that—1. Which affords a sufficiently firm support to prevent the plant from being shaken. 2. Which permits the roots to extend themselves to a distance with ease. 3. Which becomes impregnated with humidity, and retains the water sufficiently that the plant may not be without it when wanted.—To answer these several conditions, it is necessary to make a proper mixture of the primitive earths, for none of them in particular possesses them. Siliceous and calcareous earths may be considered as hot and drying, the argillaceous as moist and cold, and the magnesian as possessing intermediate properties. Each in particular has its faults, which render it unfit for culture : clay absorbs water, but does not communicate it; calcareous earth receives and gives it too quickly : but the properties of these earths are so happily opposed, that they correct each other by mixture. Accordingly we find that, by adding lime to an argillaceous earth, this last is divided; and the drying property of the lime is mitigated, at the same time that the stiffness of the clay is diminished. On these accounts it is that a single earth cannot constitute manure ; and that the character of the earth intended to be meliorated ought to be studied, before the choice of any addition is decided on. Mr. Tillet has proved that the best proportions of a fertile earth for corn, are three-eighths of clay, two eighths of sand, and three-eighths of the fragments of hard stone.

The advantage of tilling consists in dividing the earth, aërating it, destroying useless or noxious plants, and converting them into manure, by facilitating their decomposition.

Before we had acquired a knowledge of the constituent principles of water, it was impossible to explain, or even to conceive, the growth of plants by this single aliment. In fact, if the water were an element, or indecomposable principle, it would afford nothing but water in entering

into the nutrition of the plant, and the vegetable would of course exhibit that fluid only : but when we consider water as formed by the combination of the oxigenous and hydrogenous gases it is easily understood that this compound is reduced to its principles ; and that the hydrogenous gas becomes a principle of the vegetable, while the oxigene is thrown off by the vital forces. Accordingly we see the vegetable almost entirely formed of hydrogene. Oils, resins, and mucilage, consist of scarcely any thing but this substance ; and we perceive the oxigenous gas escape by the pores, where the action of light causes its disengagement. This decomposition of water is proved not only in vegetable, but likewise in animal bodies. Rondelet *(Lib. de Pisc.* lib. i. cap. xii.) cites a great number of examples of marine animals which cannot subsist but by means of water, by the very constitution of their organs. He affirms that he kept, during three years, a fish in a vessel constantly maintained full of very pure water : it grew to such a size, that at the end of that time the vessel could no longer contain it. He relates this as a very common fact. We likewise observe the red fishes, which are kept in glass vessels, are nourished, and grow, without any other assistance than that of the water properly renewed.

ARTICLE III.

Concerning Nitrogenous Gas, as a Nutritive Principle of Plants.

Vegetables cannot live without air ; but the air they require is not the same as is appropriated to man. Drs. Priestley, Ingenhousz, and Mr. Senebier, have proved that it is the nitrogenous gas which more particularly serves them for aliment.* Hence it arises that vegetation is more vigorous when a greater quantity of those bodies which

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* If this opinion was just, vegetables growing in atmospheric air would abstract the nitrogene gas, and render it purer, but this is never the case. A branch of Sedum Telephium, a vigorous evergreen, will grow twenty days in the air of the atmosphere, and produce no effect upon it.—*Am. Ed.*

afford this gas by their decomposition are presented to the plant; these are, animals or vegetables in a state of putrefaction. As the basis of nitrogenous gas is unknown to us, it is difficult to conceive what may be its effect upon the vegetable economy, and we cannot follow it after its introduction into the vegetable. We do not find it again until the decomposition of the vegetable itself, when it re-appears in its gaseous form.

ARTICLE IV

Concerning the Carbonic Acid, as a Nutritive Principle of Vegetables.

The carbonic acid which is dispersed in the atmosphere, or in waters, may likewise be considered as an aliment of plants; for these bodies possess the power of absorbing and decomposing it when its quantity is small. The base of this acid even seems to contribute to the formation of vegetable fibres: for I have observed that this acid predominates in the fungus, and other subterraneous plants. But by causing these vegetables, together with the body upon which they were fixed, to pass by imperceptible gradations from an almost absolute darkness into the light, the acid very nearly disappeared; the vegetable fibres being proportionally increased, at the same time that the resin and colouring principles were developed by the oxigene of the same acid. Senebier has observed, that the plants which he watered with water impregnated with the carbonic acid, transpired a much greater quantity of oxigenous gas; which proves a decomposition of the carbonic acid.

Vegetation may therefore be successfully employed to correct air too highly charged with carbonic acid, or in which the nitrogenous gas exists in too great a proportion.

ARTICLE V.

Concerning Light, and its Influence on Vegetation.

Light is absolutely necessary to plants. Without the assistance of this principle they become pale, languish, and die. But it has not been proved that it enters as an aliment into their composition : at most it may be considered as a stimulus or agent which decomposes the various nutritive principles, and separates the oxigenous gas arising from the decomposition of the carbonic acid, while their bases become fixed in the plant itself.

The most immediate effect of the fixation of the various substances, and the concretion of the liquids, which serve as the food of plants, is a sensible production of heat, which causes plants to participate very little in the temperature of the atmosphere. Dr. Hunter observed, by keeping a thermometer plunged in a hole made in a sound tree, that it constantly indicated a temperature several degrees above that of the atmosphere, when it was below the fifty-sixth division of Fahrenheit; whereas the vegetable heat in hotter weather, was always several degrees below that of the atmosphere. The same philosopher has likewise observed, that the sap, which out of the tree would freeze at 32°, did not freeze in the tree unless the cold were augmented 15° more.

The vegetable heat may increase or diminish, by several causes, of the nature of disease ; and it may even become perceptible to the touch in very cold weather, according to Mr. Buffon.

The heat produced in healthy vegetables, by the before-mentioned causes continually tempers the cold of the atmosphere ; the evaporation which takes place through the whole body of the tree, continually moderates the scorching heat of the sun : and these productive causes of cold or heat are more effectual, in proportion as the heat or cold of external bodies acts with greater energy.

The property which plants possess of converting nitrogenous gas and carbonic acid into nourishment, establishes an astonishing degree of analogy between them and

certain insects.   It appears, from the observation of Frederic Garman (Ephem. des Curios. Nat. Année 1670), that the air may become a real food for the class of spiders.   The larvæ of the ant, as well as of several insects of prey which live in the sand, increase in bulk, and undergo their metamorphoses without any other nourishment than that of the air.   It has been observed that a great number of insects, particularly in the state of larvæ, are capable of living in the nitrogenous gas, mixed with carbonic acid, and transpiring vital air.   The abbé *Fontana* has observed that several insects possess this property ; and *Ingenhousz*, who is of opinion that the green matter which is formed in water, and transpires oxigenous gas by the light of the sun, is a cluster of animalculæ, has added to these phenomena.*   Insects have moreover the organ of respiration distributed over the whole surface of their bodies.   Here therefore we observe several very astonishing points of analogy between insects and vegetables : and the chymical analysis adds still more to these resemblances, since insects and vegetables afford the same principles ; namely, volatile oils, resins, disengaged acids, &c.

SECTION III.

Concerning the Results of Nutrition, or the Vegetable Principles.

THE various substances which afford food to plants, are changed by the organization of the vegetable; from which there results a fluid generally distributed, and known by the name of Sap.   This juice when conveyed into the several parts of the plant, receives an infinity of modifications, and forms the several humours which are separated and afforded by the organs.   It is to these principles chiefly that we are at present about to direct

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* This green matter is now considered by all philosophers, to be a vegetable substance.—*Am. Ed.*

our attention; and we shall endeavour in our examination to follow the most natural order, by subjecting them to analysis in the same order as that in which nature presents them to us.

ARTICLE II.

Concerning Mucilage.

Mucilage appears to constitute the first alteration of the alimentary juices in vegetables.   Most seeds are almost totally resolvable into mucilage, and young plants seem to be entirely formed of it.   This substance has the greatest analogy with the mucous fluid of animals.   Like that fluid, it is most abundant in the earlier periods of life ; and all the other principles appear to be derived from it; and in vegetables, as well as animals, its quantity becomes less in proportion as the increase of magnitude, or growth of the individual, becomes less, or ceases.   Mucilage is not only the nutritive juice of plants and animals ; but, when extracted from either, it becomes the most nourishing and wholesome food we are acquainted with.

Mucilage forms the basis of the proper juices, or the sap of plants.   It is sometimes found almost entirely alone, as in mallows, the seeds of the wild quince, linseed, the seeds of thlaspi, &c.   Sometimes it is combined with substances insoluble in water, which it keeps suspended in the form of an emulsion ; as in the euphorbium, celandine, the convolvulus, and others.   In other instances it is united with an oil, and forms the fat oils. Frequently it is united with sugar ; as in the gramineous seeds, the sugar-cane, maize, carrot, &c.   It is likewise found confounded with the essential salts, with excess of acid, as in barberries, tamarinds, sorrel, &c.

Mucilage sometimes constitutes the permanent state of the plant ; as in the tremella, the conferva, some lichens, and most of the champignons.   This existence in the form of mucilage is likewise seen in certain

animals; such as the medusa or sea-nettle, the holothu-
rion, &c.

The characters of mucilage are—1. Insipidity. 2.
Solubility in water. 3. Insolubility in alcohol. 4. Coa-
gulation by the action of weak acids. 5. The emission
of a considerable quantity of carbonic acid, when ex-
posed to the action of fire; at the same time that it be-
comes converted into coal, without exhibiting any flame.
Mucilage is likewise capable of passing to the acid fermen-
tation when diluted with water.

The formation of mucilage appears to be almost in-
dependent of light. Those plants which grow in sub-
terraneous places abound with it. But light is required
to enable mucilage to pass to other states; for, without
the assistance of this principle, the same plants would
obtain scarcely any consistence.

That which is called gum, or gummy juices, in com-
merce, is nothing but dried mucilage. These gums are
three in number. They either flow naturally from the
trunk of the tree which affords them, or they are obtained
by incision of the bark.

1. Gums of the country, *Gummi nostras.*—This gum
flows naturally from certain trees in our climate, such as
the plum, the peach, the cherry-tree, &c. It first appears
in the form of a thick fluid, which congeals by exposure
to the air, and loses the adhesive and gluey consistence
which characterizes it in the liquid state. Its colour is
white, but more commonly yellow or reddish. When
pure, it may be advantageously substituted for gum ara-
bic, which is much dearer.

2. Gum arabic.—The gum arabic flows naturally from
the acacia in Egypt and Arabia. It is even affirmed that it
is not obtained from this tree only, but that the gum met
with in commerce is the produce of several trees. The
appearance of this gum is in round pieces, white and
transparent, wrinkled without and hollow within; it is
likewise found in round pieces variously contorted. This
gum is easily soluble in water, and forms a transparent
jelly called mucilage. It is much used in the arts and in
medicine. It is mild, void of smell or taste, very well
adapted to serve as the basis of pastils, and other prepar-
ations used as mitigating or softening remedies.

3. Gum adragant.—The gum adragant is nearly of the
same nature as gum arabic.   It flows from the adragant
of Crete, a small shrub not exceeding three feet in
height.   It comes to us in small white tears, contorted,
and resembling little worms.   It forms with water a thick-
er jelly than gum arabic, and may be used for the same
purposes.

If the roots of marshmallows or of the consolida, linseed,
the kernels of the wild quince (coing), &c. be macerated
in water for a time they afford a mucilage similar to that
of gum arabic.

All these gums afford by distillation, water, an acid, a
small quantity of oil, a small quantity of ammoniac or vo-
latile alkali, and much coal.   This sketch of analysis
proves that mucilage is composed only of water, oil, acid,
carbone, and earth ; and shews that the various princi-
ples of the alimentary juices, such as water, the carbonic
acid, and nitrogene gas, are scarcely changed in this
substance.

Gums are used in the arts and in medicine.   In the arts
they are applied to give a greater degree of consistence
to certain colours, and to fix them more permanently
upon paper; they are also used as a preparation to give a
firmer body to hats, ribands, taffetas, &c.   Stuffs dipped
in gum water acquire a lustre and brightness ; but water,
and the handling of these goods, soon destroy the illusion;
and these processes are classed among those which nearly
approach to imposition and deceit.   Gum is likewise the
basis of most kinds of blacking used for shoes, boots,
and the like.

The gums are ordered in medicine as emollients.
They compose the basis of many remedies of this
kind.   The mucilage of linseed, or of the ker-
nels of wild quinces, is of value in allaying inflamma-
tions.

ARTICLE II.

Concerning Oils.

By common consent the name of Oil is given to fat unctuous substances, more or less fluid, insoluble in water, and combustible.

These products appear to belong exclusively to animals and vegetables. The mineral kingdom exhibits only a few substances of this nature, which possess scarcely any of the above properties, such as the unctuous property.

Oils are distinguished, relative to their fixity, into fat oils, and essential oils. We shall describe them in this article under the names of Fixed Oils and Volatile Oils. The difference between these two kinds of oils do not merely consist in their various degrees of volatility, but also in their habitudes with the several re-agents. The fixed oils are insoluble in alcohol, but the volatile oils are easily dissolved : the fixed oils are in general mild ; while the volatile are acrid and even caustic.

It appears nevertheless that the oily principle is the same in both ; but it is combined with mucilage in the fixed oils, and with the spiritus rector, or aroma, in the volatile oils. By burning the mucilage of fixed oils by distillation, they become more and more attenuated; the same may likewise be done by means of water, which dissolves this principle. By distilling volatile oil with a small quantity of water, by the gentle heat of a water bath, the aroma is separated; and this may be again restored by re-distilling it with the odorant plant which originally afforded it.

Volatile oil is usually found in the most odorant part of any plant. In umbelliferous plants it is found in the seed; in the geum, the root affords it ; and in the labiated plants it is found in the branches and leaves. The simi-

litude between volatile oils and ether, which appears to be
merely a combination of oxigene and alcohol, proves that
the volatile oils may be nothing but a combination of
the fermentescible basis of sugar with oxigene.   Hence
we may form a notion how oil is formed in the distil-
lation of mucilage and of sugar; and we shall no
longer be surprised to find that the volatile oils are acrid
and corrosive, that they redden blue paper, attack and
destroy cork, and approach to the properties of acids.
We shall now proceed to treat of fixed and volatile oils
separately.

DIVISION I.

Concerning Fixed Oils.

Most of the fixed oils are fluid; but the greater num-
ber are capable of passing to the state of solidity, even
by a moderate degree of cold.   There are some which
constantly possess that form in the temperature of our
climates; such as the butter of cacao, wax, and the pe-
la of the Chinese.   They all congeal at different degrees
of cold.   Olive oils become solid at 10° below zero of
Reaumur; oil of almonds at the same degree; but nut-
oil does not freeze in our climates.

The fixed oils possess a very evident degree of unctu-
osity, do not mix either with water or alcohol, are vola-
tilized at a degree of heat superior to that of boiling wa-
ter, and when volatilized they take fire by the contact of
an ignited body.

The fixed oils are contained in the kernels of shell fruits
or nuts; in the pippins, and sometimes in all the parts of
fruits, such as olives and almonds, all whose parts are ca-
pable of affording them.

The oil is usually made to flow by expression out of
the cellules which contain it : but each species requires a
different management.

1. Olive oil is obtained by expression from the fruit of
the olive tree.   The process used by us is very simple.

The olive is crushed by a mill-stone, placed vertically, rolling upon an horizontal plane. The paste thus formed is strongly pressed in a press; and the first oil which comes out is called Virgin Oil. The marc or pulp is then moistened with boiling water; the mass is again pressed; and the oil which floats upon the water carries with it part of the parenchyma of the fruit, and a great part of the mucilage, from which it is difficultly cleared.

The difference in the kind of olive produces a difference in the oil; but the concurrent circumstances likewise establish other differences. If the olive be not sufficiently ripe, the oil is bitter; if it be too ripe, the oil is thick and glutinous. The method of extracting the oil has a very great influence on its quality. The oil mills are not kept sufficiently clean; the mill-stones, and all the utensils, are impregnated with a rancid oil, which cannot but communicate its flavour to the new oil. In some countries it is usual to lay the olives in heaps, and suffer them to ferment before the oil is drawn. By this management the oil is bad; and this process can only be used for oil intended for the lamp or for the soap-boiler.

2. Oil of almonds is extracted from that fruit by expression. For this purpose dry almonds are put into a coarse sack, and agitated rather strongly, to disengage an acrid powder which adheres to the skin. They are then pounded in a marble mortar into a paste, which is wrapped in a coarse cloth, and subjected to the press.

This oil is greenish and turbid when fresh, because the action of the press causes part of the mucilage to pass through the cloth; as it becomes older it is clearer, but is acrid by the decomposition of the same mucilage.

Some persons throw almonds into hot water, or expose them to steam, before they press them; but this addition of water disposes the oils to become rancid more speedily.

By this process the oil of all kinds of almonds, nuts, and seeds, may be extracted.

3. Linseed oil is extracted from the seed of the plant linum. As this seed contains much mucilage, it is torrefied before it is subjected to the press. This previous treatment gives the oil a disagreeable empyreumatic flavour; but at the same time deprives it of the property of

becoming rancid, and renders it one of the most drying oils. All mucilaginous seeds, all kernels, and the seeds of henbane and of the poppy, ought to be treated in the same manner.

If a fat oil be distilled in a proper apparatus of vessels, the product is, phlegm; an acid; a fluid or light oil, which becomes thicker towards the end; much hydrogenous gas, mixed with carbonic acid; and a coaly residue, which affords no alkali. I have observed that the volatile oils afford more hydrogenous gas, and the fixed more carbonic acid: this last product depends on the mucilage. By distilling the same oil repeatedly, it is more and more attenuated, becomes very limpid and very volatile, with the only difference that it has required the peculiar odour communicated by the fire. The volatilization of the oil may be accelerated by distilling it from an argillaceous earth; by this means it is in a short time deprived of its colouring part: and the heavy oils which afford bitumens, when distilled once or twice from clay alone, such as that of Murviel, are rendered perfectly colourless. The ancient chemists prepared *oleum philosophorum* by distilling oil from a brick previously impregnated with it.

1. Oil easily combines with oxigene. This combination is either slow or rapid. In the first case, rancidity is the consequence; in the second inflammation.

Fixed oil exposed for a certain time to the open air, absorbs the oxigenous gas, and acquires a peculiar odour of fire, an acrid and burnt taste, at the same time that it becomes thick and coloured. If oil be put in contact with oxigene in a bottle, it becomes more speedily rancid, and the oxigene is absorbed. Scheele observed the absorption of a portion of the air before the theory was well ascertained. Oil is not subject to alteration in closed vessels.

It seems that oxigene, combined with the mucilage, constitutes rancidity; and that, when combined with the oil itself, it forms drying oil.

The rancidity of oils is therefore an effect analogous to the calcination or oxidation of metals. It essentially depends on the combination of pure air with the extractive principle, which is naturally united with the oily principle. We may carry this inference to demonstration, by

attending to the processes used to counteract or prevent the rancidity of oils.

A. When olives are prepared for the table, every endeavour is used to deprive them of this principle, which determines their fermentation; and for this purpose various methods are used. . In some places they are macerated in boiling water, charged with salt and aromatics; and, after twenty-four hours digestion, they are steeped in clear water, which is renewed until their taste is perfectly mild. Sometimes nothing more is done than to macerate the olives in cold water; but they are frequently macerated in a lixivium of quick-lime and wood ashes, after which they are washed in clear water. But in whatever manner the preparation is made, they are preserved in a pickle charged with some aromatic plant, such as coriander and fennel. Some persons preserve them whole; others split them, for the more complete extraction of their mucilage, and in order that they may be more perfectly impregnated with the aromatics.

All these processes evidently tend to extract the mucilaginous principle, which is soluble in water, and by this means to preserve the fruit from fermentation. When the operation is not well made, the olives ferment and change. If olives be treated with boiling water, to extract the mucilage, before they are submitted to the press, a fine oil will be obtained, without danger of rancidity.

B. When the oil is made, if it be strongly agitated in water, the mucilaginous principle is disengaged; and the oil may be afterwards preserved for a long time without change. I have preserved oil of the marc of olives, prepared in this manner, for several years, in open bottles, without any alteration.

C. The torrefaction to which several mucilaginous seeds are subjected before the extraction of the oil, renders them less susceptible of change, because the mucilage has been destroyed.

D. M. Sieffert has proposed to ferment oils with apples or pears, in order to deprive rancid oils of their acrimony. By this means they are cleared of the principle which had combined with them, but now becomes attached to other bodies.

Mucilage may therefore be considered as the seed of fermentation.

When the combination of the pure air is favoured by the volatilization of the oil, inflammation and combustion are then the consequence. To carry this combination into effect, the oil must be volatilized by the application of a heated body; and the flame which is produced is then sufficient to maintain the degree of volatility, and support the combustion. When a current of air is caused to pass through the middle of the wick and the flame, the great quantity of oxigene which must then necessarily pass, occasions a more rapid combustion. Hence it is that the light is stronger, and without smoke; for this is destroyed and consumed by the violent heat which is excited.

The lamps of Palmer are likewise entitled to our particular attention. By causing the rays to pass through a liquor coloured blue, he perfectly imitates the light of the day; which proves that the artificial rays require to be mixed with the blue, to imitate the natural: and the solar rays which pass through the atmosphere, may owe their colour to their combination with the blue colour which appears to predominate in the air.

If water be projected upon oil in a state of inflammation, it is known that extinction does not happen, because the water is decomposed in this experiment. If the product of the combustion of oil be collected, much water is obtained, because the combination of its hydrogene with oxigene produces that fluid.

Mr. Lavoisier has proved that one pound of olive oil contains,

Coal or carbone, 12 ounces, 5 gross, 5 grains;
Hydrogene, -   3   —   2   — 67.

The art of rendering oils drying, likewise depends on the combination of oxigene with the oil itself. For this purpose, nothing more is required than to boil it with oxides. If an oil be heated upon the red oxide of mercury, a considerable ebullition ensues, the mercury is reduced, and the oil becomes very drying: this is an observation of Mr. Puymaurin. The oxides of lead or copper are commonly used for this purpose. An exchange of principles takes place in this operation; the

mucilage combines with the metal, while the oxigene unites with the oil.

Oil may likewise be combined with the metallic oxides by double affinity, after the manner of Berthollet. For this purpose a solution of soap is poured into a metallic solution. By this means a soap of a green colour is prepared with a sulphate of copper; and, with that of iron, a soap of a deep brown colour, of considerable intensity.

It appears that, in the combinations of fixed oils with the oxides of lead, a substance is disengaged, and swims at the top, which Scheele called the Sweet Principle, and seems to be simply mucilage.

2. Oil combines with sugar, and affords a kind of soap, which may be easily diffused in water, and kept suspended. The trituration of almonds with sugar and water, forms the lac amygdale, orgeat, and other emulsions. Combinations of this kind exist ready formed in the vegetable kingdom.

3. Oil unites readily with alkalis; and the result of this union is the well known compound soap. To this effect, potash or pure alkali may be triturated with oil, and the mixture concentrated by fire. The medicinal soap is made with oil of sweet almonds, and half its weight of potash or caustic alkali. The soap becomes hard by standing.

To make the soap of commerce, one part of good soda of Alicant must be boiled with two of quicklime; in a sufficient quantity of water. The liquor is then to be strained through a cloth; and evaporated to that degree, that a phial which contains eight ounces of pure water, may hold eleven of the saline solution, which is usually called Soap Lye or Lees. One part of this lixivium, and two of oil, boiled together, till upon trial with a spatula it easily separates, and soon coagulates, form soap.

In most manufactories the lixivium is prepared without heat. Equal volumes of pounded soda of Alicant, and quicklime previously slacked, are mixed together. Water is thrown on this mixture, which filters through, and is conveyed into a proper vessel. Water is poured on till it passes through without acquiring any more salt. In

this way these kinds of leys are obtained, which differ in strength; that which passes first is the strongest, and the last is almost mere water. These are afterwards mixed with oil in boilers, where the mixture is favoured by heat. The weak lye is first added, and afterwards gradually the stronger; and the strongest is not added till towards the end of the process.

To make the soap marbled, they make use of soda in the mass, blue copperas, cinnabar, &c. according to the colour desired.

A liquid green or black soap is likewise made by boiling the lixivium of soda, potash, or even wood ashes, with the marc of the oils of olive, of nuts or of nape; or with fat, or fish oil, &c. The black soap is made in Picardy, and the green in Holland. The Marquis de Bouillon has proposed to make soaps with animal fat.*

At Aniane, and in the neighbourhood of Montpellier, a soft soap is prepared with caustic lixivium of wood ashes, and the oil or the marc of olives.

If soap be exposed to distillation, the result is water, oil, and much ammoniac; and there remains in the retort a large quantity of the alkali used in the fabrication of the soap. The ammoniac which is produced in this experiment, appears to me to arise from the combination of the hydrogenous gas of the oil with the nitrogene, a constituent principle of the fixed alkali.

Soap is soluble in pure water; but it forms curds, and is decomposed in water abounding with sulphates: because the sulphuric acid seizes the alkali of the soap; while the earth combines with the oil, and forms a soap which swims at the surface.

Soap is likewise soluble in alcohol by the assistance of a gentle heat; and forms the essence of soap, or opodeldoc, which may be scented at pleasure.

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* All the soap manufactured in America is made with animal fat. The fat is boiled in a caustic lye, made of vegetable ashes, which contain potash, and forms soft soap. Upon adding a solution of sea salt to this, a double elective attraction takes place; the muriatic acid of the salt unites to the potash, and forms muriate of potash, or digestive salt of Sylvius, while the soda of the salt unites to the fat, and forms hard soap.—*Am. Ed.*

Soaps are capable of combining with a larger quantity of oil, and rendering it soluble in water. Hence their property of cleansing cloths, linens, &c. They are used as deobstruents in medicine.

4. The fixed oils unite likewise with acids. Messrs. Achard, Cornette, and Macquer, have attended to these combinations. Achard gradually adds the concentrated sulphuric acid to the fixed oil; the mixture being triturated, a mass is obtained which is soluble in water and in alcohol.

The fuming nitric acid immediately turns the fixed oils black, and sets fire to such as are drying. It is in this case decomposed with a rapidity so much the greater, as the oil has a greater affinity with the oxigene. On this account it is that the inflammation of the drying oils is more easily effected than that of the others.

Those acids whose constituent parts adhere most strongly together, have but a very feeble action on oils; a circumstance which proves that the effect of acids upon oils is principally owing to the combination of their oxigene.

It is by virtue of this strong affinity of oils with oxigene, that they possess the power of reviving metals. The oxigene then quits the metal, and unites with the oils, which become thick and coloured. It likewise follows from hence that drying oils ought to be preferred for this use; and we find that practice agrees with theory in this respect.

DIVISION II.

Concerning Volatile Oils.

Fixed oil is combined with mucilage, volatile oil with the spiritus rector, or aroma; and it is this combination or mixture which constitutes the difference between them. The volatile oils are characterized by a

strong smell, more or less agreeable; they are soluble in alcohol, and have a penetrating and acrid taste. All the aromatic plants contain volatile oil, excepting those whose smell is very transient, such as jessamine, violets, lilies, &c.

The volatile oil is sometimes distributed through the whole plant, as in the Bohemian angelica; sometimes it exists in the bark, as in cinnamon. Balm, mint, and the greater absinthium, contain their oils in the stem and leaves; elicampane, the iris of Florence, and the caryo-phyllata, in the root. All the resinous trees contain it in their young branches; rosemary, thyme and wild thyme, contain their essential oils in their leaves and buds; laven-der, and the rose, in the calyx of their flowers; cammo-mile, lemon, and orange trees, in the petals. Many fruits contain it through their whole substance, such as pepper, juniper, &c. Oranges and lemons in the zest and peeling which inclose them. The seed of umbelliferous plants, such as anise and fennel, have the vesicles of essential oil arranged along the projecting lines upon their skin: the nutmeg tree contains its essential oil in the nut itself. —See *L'Introduction à l'Etude du Regne Veg. par M. Buquet*, p. 209—212.

The quantity of volatile oil varies according to the state of the plant. Some afford most when green, others when dry; but the latter constitute the smallest number. The quantity likewise varies according to the age of the plant, the soil, the climate, and the time of extraction.

The volatile oils likewise differ in their consistence. Some are very fluid, as those of lavender, rosemary, and rue; the oils of cinnamon and sassafras are thicker; there are some which constantly preserve their fluidity; others which become concrete by the slightest impression of cold, as those of aniseed and fennel: others again possess the concrete form, such as those of roses, of parsley, and of elicampane.

The volatile oils likewise vary in their colour. The oil of roses is white; that of lavender, of a light yellow; that of cinnamon, of a brown yellow; the oil of cammomile is of a fine blue; that of millefoil, of a sea-green; that of parsley, green, &c.

The weight is likewise different in the different kinds. The oils of our climates are in general light, and swim upon water; others are nearly of the same weight; and others are heavier, such as the oils of sassafras and of cloves.

The smells of essential oils vary according to those of the plants which produce them.

The taste of the volatile oils in general is hot; but the taste of the plant does not always influence that of the oil; for example, the oil of pepper has no acrimony, and that which is obtained from wormwood is not bitter.

We are acquainted with two methods of extracting the volatile oils—expression and distillation.

1. Those oils which are, as it were, in a naked state, and contained in projecting and visible receptacles, are obtained by expression. Such are those of citrons, o-ranges, cedrat, and bergamotte; the oil issues out of the skin of these fruits when pressed. It may therefore be procured by a strong pressure of the peeling against an inclined glass. In Provence and in Italy they are rasped; by which means the vesicles are torn, and the oil flows into the vessel destined to receive it: this oil suffers the parenchyma which goes along with it to subside, and be-comes clear by standing.

If a lump of sugar be rubbed against these vesicles, it imbibes the volatile oils; and forms an oleo-saccharum, soluble in water, and very proper to give an aromatic fla-vour to certain liquids.

2. Distillation is the method most commonly used in the extraction of volatile oils. For this purpose, the plant or fruit which contains the oil is placed in the boiler or body of the alembic. A quantity of water is then pour-ed in, sufficient to cover the plant, and the water is heat-ed to ebullition. The oil which rises with this degree of heat, comes over with the water, and is collected at the surface in a particular receiver, called the Italian receiver, which suffers the surplus of water to escape by a spout is-suing from the belly of the vessel, whose orifice is low-er than that of the neck of the receiver; so that by this means the oil is collected in the neck, without a possibi-lity of its escaping.

The water which passes over in distillation is more or less charged with oil, and the odorant principle of the plant, and forms what is known by the name of Distilled Water. These waters ought to be returned again into the cucurbit when the same kind of plant is again distilled; because, being saturated with oil, and the aromatic principle, they contribute to augment the ulterior product.

When the oil is very fluid or very volatile, it is necessary to annex a worm pipe to the alembic, and to have the precaution of keeping the water at a very cold temperature; but when, on the contrary, the oil is thick, the worm pipe must be removed, and the water of the refrigeratory kept at a moderate temperature. In the first way, the oils of balm, mint, sage, lavender, camomile, &c. may be distilled; and, by the second, the oils of roses, of elicampane, of parsley, of fennel, of cumin, &c.

The oil of cloves may likewise be extracted by distillation per descensum, which is determined by applying the fire above the material.

Volatile oils are very subject to be adulterated, either by mixture with fat oils, or with other essential oils, such as that of turpentine, which is cheaper; or by mixing them with alcohol. In the first case the fraud is easily detected—1. By distillation, because volatile oils rise at the heat of boiling water. 2. By causing blotting paper to imbibe some of the mixture, and exposing it to a degree of heat sufficient to drive off the volatile oil. 3. By means of alcohol, which becomes turbid and milky by the insolubility of the fixed oil.

The volatile oils which have a very strong smell, such as those of thyme and lavender, are often sophisticated by oil of turpentine. In this case the fraud may be discovered by soaking a small piece of cotton in the mixture, and leaving it exposed to the air a sufficient time for the smell of the good oil to be dissipated, and leave only that of the adulteration. The same end may be answered by rubbing a small quantity of the mixture on the hand, in which the peculiar smell of oil of turpentine is developed. These oils are likewise falsified by digesting the plant in oil of olive before distillation. In this manner the oil of camomile is prepared.

The very light oils, such as those of cedrat or berga-motte, are often mixed with a small quantity of alcohol. This fraud is easily detected by the addition of a few drops of water, which immediately become white, be-cause the alcohol abandons the oil to unite with the water.

The volatile oils are capable of uniting with oxigene, with alkalis, and with acids.

1. Volatile oils absorb oxigene with greater facility than the fixed oils. They become coloured by the absorption, grow thicker, and pass to the state of resin; and when they are thickened to this point, they are no longer capa-ble of fermenting, but secure from all putrefaction such bodies as are penetrated and well impregnated with them. On this is founded the theory of embalming.—The ac-tion of acids upon these oils, causes them to pass to the state of resin; and there is no other difference between volatile oil and resin, than that which arises from this ad-dition of oxigene.

All the oils, when they assume the character of resin by this combination of oxigene, let fall needle-formed crystals of camphor. Mr. Geoffroy has observed them in the oil of fever few, marjoram, and turpentine. Acad, 1721, p. 163.

When the oil is changed by the combination of oxi-gene, it gradually loses its smell and volatility. To re-store this oil to its original state, it is distilled. A thick matter remains in the distilling vessel, which consists of resin perfectly formed, and is thus separated from the oil, which has not yet undergone the same alteration.

5. The habitudes of acids are not the same with all volatile oils. 1. The concentrated sulphuric acid thick-ens them: but, if it be diluted, it forms savonules. 2. The nitric acid, when concentrated, inflames them; but, when diluted, it causes them gradually to pass to the state of resin. Borrichius appears to have been the first who inflamed oil of turpentine with the sulphuric acid, with-out the nitric acid. Homberg repeated this delicate ex-periment with the other volatile oils. The inflammation of oils is so much the more easily effected, as the oil is more drying or greedy of oxigene, and the acid more ea-sily decomposed. 3. The muriatic acid reduces oils to

the saponaceous state, but the oxigenated muriatic acid thickens them.

3. Starkey appears to have been one of the first who attempted to combine a volatile oil with a fixed alkali. His process is long and complicated, like those of the alchymists; and the combination it afforded was known by the name of Starkey's Soap. The process of this chemist was so long merely because he used the carbonate of potash, or mild vegetable alkali; but if ten parts of caustic alkali, or *lapis causticus*, be triturated hot with eight parts of oil of turpentine, the soap is instantaneously formed, and becomes very hard. This is the process of Mr. Geoffroy.—Acad. des Sciences, ann. 1725.

Concerning Camphor.

Camphor is obtained from a species of laurel which grows in China and Japan. Some travellers affirm that the old trees contain it so abundantly, that on splitting the trunk it is found in large tears, so pure as to have no need of rectification. To extract the camphor, the roots of the trees are usually chosen; or, in want of these, all the other parts of the tree. These are put, together with water, into an iron alembic, which is covered with its head. The capital is fitted up internally with cords of rice straw, the joinings are luted, and the distillation proceeded upon. Part of the camphor sublimes, and attaches itself to the straw within the head; while another portion is carried into the receiver with the water. The Hollanders purify camphor by mixing an ounce of quicklime with every pound of the substance, and subliming it in large glass vessels.*

* Crude camphor is imported by the American merchants from Canton and Batavia, where it is bought for fifty and seventy-five cents, and sells in this country, from a dollar, to a dollar and eleven cents a pound.

The apparatus necessary for refining this article is simple, does not cost much, and occupies little room.

It consists of a furnace, supporting a sand-bath, glass vessels, and iron, copper or earthen pans.

Camphor, thus purified, is a white concrete crystalline substance, of a strong smell and taste, soluble in alcohol, burning with a white flame, and leaving no residue : resembling volatile oils in many respects, but differing from

I. OF THE CONSTRUCTION OF THE FURNACE.

A furnace sufficiently large for one active and industrious man to attend, will occupy the space of eight feet nine inches in length, and two feet six inches in breadth. It must be made of seven cast iron plates, half an inch thick, thirty inches long, and fifteen broad. These plates are to be placed upon eight piles of bricks, parallel to each other, and nine inches apart. The bricks are to be ten inches high, thirty long, and six broad.

Great care must be taken, that the lower sides of the plates meet each other exactly midway on the upper side of the bricks, which should be well covered, with a thick bed of mortar. Bricks serve to confine the sand. When the furnace is connected with a wall, there is no occasion for more than a single row of them : and to obtain a considerable draught of air, a chimney should be carried from the fourth plate with an aperture four inches in diameter, and the flues of the third and fifth plate, may communicate with this chimney. Two separate flues may be carried from the second and sixth plates, and the first and seventh should enter the second and sixth.

The chimney, if convenient, may be made to enter into that of the house, but if not, it should be about fifteen feet high.

II. OF THE GLASS VESSELS.

The vessels are procured at a glass-house, and are made of green glass. They should be blown as thin as an oil flask. They are of a circular form, shaped flat like a turnip, and have a neck from one to three inches high, with an aperture, from half an inch to one inch in diameter. Their bottoms should be eleven inches broad, and the top ought to be four inches from the bottom.

They cost twenty-five dollars a hundred in Philadelphia.

III. OF THE PANS.

Fourteen pans may be made of iron, copper or earth. Sheet iron is the best material. They should be round, one foot in diameter, with a rim pecked on four inches and a half high, and ought to have two small handles. They cost one dollar a-piece in this city.

Having prepared this necessary apparatus, the next thing is to make use of it, in such a manner as to refine the camphor.

Having taken the article out of the tubs, the glass vessels are to be filled two-thirds full of it, and the apertures in the necks, slightly stopped, with paper or cotton plugs. They are then to be placed on

them in certain properties; such as that of burning without a residue; of dissolving quietly, without decomposition or alteration, in acids; and of being volatilized by a gentle heat, without change of its nature.

Camphor is obtained by distillation from the roots of zedoary, thyme, rosemary, sage, the inula helenium, the

the bottom of the pans, and covered near to the base of their necks with sand.

The pans, holding the vessels containing the camphor, are to be carried to the sand-bath, and surrounded near to the top of the rim with sand.

A gentle fire is to be kindled in the furnace, at four o'clock in the morning, and gradually increased, until the camphor melts, which it does when it arrives at 304° of Fahrenheit's thermometer. It will first rise in flowers, which will dissolve and run down the sides of the vessel. When it has melted, or is boiling, the glass is to be elevated in such a manner that the hot sand, may reach only to the middle of its belly, in order that the cool air may be admitted to the upper surface of the glass, to congeal the camphor as it sublimes.

Having kept it in a liquid or boiling state, from eight to ten hours, the refined camphor will be found, adhering to the upper side of the vessel, and is to be taken from it by breaking the glass while hot, or it may be kept until cool and then broken. The glass is easily separated from it, by means of a knife.

The foul parts which adhere to the bottom of the glass, and which cannot be easily parted from it, are to be broken into pieces, and sublimed a second time, with an additional supply of camphor.

When the crude camphor is of a white colour, or contains little foreign matter, no addition is to be made to it; but when it is brown or black, one ounce of slacked or quick lime, is to be mixed with every three or four pounds of it. The utility of lime in this operation is noticed by Margraff.

One man can refine and pack up, from eighteen to twenty-five pounds every day.

If any of the glass vessels holding the melted camphor should crack, which sometimes happens, and which is discovered, by the flowers rising into the air from their sides and tops, the pans containing it are to be immediately removed to a cool place; and if the camphor is found mixed with the sand, the whole is to be put into other vessels, and the operation conducted as before.

The loss in refining one hundred weight of this article cannot be accurately ascertained, as it depends upon the purity of the crude material, and the care in conducting the process. It cannot be very great.

Professor Robertson, in a note to Dr. Black's Chemistry informs us, that in a manufactory in Holland, he saw more than one hundred vessels in a furnace at one time, and that there was but a moderate smell of camphor in the room.—*Am. Ed.*

anemony, the pasque flower or pulsatilla, &c. And it is to be observed, that all these plants afford a much greater quantity of camphor when the sap has been suffered to pass to the concrete state, by a desiccation of several months. Thyme and pepper mint, slowly dried, afford much camphor; whereas the fresh plants afford volatile oil: most of the volatile oils, in passing to the state of resin, also let fall much camphor. Mr. Achard has likewise observed that a smell of camphor was disengaged when he treated the volatile oil of fennel with acids. The combination of the diluted nitric acid with the volatile oil of anise, afforded him a large quantity of crystals, which possessed most of the properties of camphor. He obtained a similar precipitate by pouring the vegetable alkali upon vinegar saturated with the volatile oil of angelica.

From all these facts it appears, that the base of cam phor forms one of the constituent principles of some volatile oils; but it is in the liquid state, and does not become concrete but by combining with oxigene.*

Camphor is capable of crystallization, according to Mr. Romieu, whether in sublimation, or when it is slowly precipitated from alcohol, or when alcohol is supersaturated with it; it precipitates in slender filaments, crystallizes in hexagonal blades attached to a common axis, and it sublimes in hexagonal pyramids or in polygonal crystals.

Camphor is not soluble in water; but it communicates its smell to that fluid, and burns on its surface. Romieu has observed that small pieces of camphor, of one-third or one-fourth of a line in diameter, being placed on the surface of pure water in a glass, have a rotatory motion: and this appears to be an electrical phænomenon; for the motion ceases if the water be touched with a conducting substance; but continues if it be

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* Camphor may be formed artificially, by passing a current of muriatic acid gas, through the spirit of turpentine. When made in this manner it differs from the Laurel Camphor in its taste, which is not so bitter; in its odour, which is not so penetrating, and in the effect produced upon it by the nitric and acetic acids, the first of which dissolves it by a reciprocal decomposition; the latter not at all; while both dissolve camphor rapidly.—*Am Ed.*

touched with an insulating body, such as glass, sulphur,
or resin.   Bergen has observed that camphor does not
turn upon hot water.

Acids dissolve camphor without producing any altera-
tion in it, or becoming themselves decomposed : the nitric
acid dissolves it quietly; and this solution has been called
Oil of Camphor.   Camphor precipitated from its solu-
tion in acids by the addition of alkalis, is heavier, harder
and much less combustible, according to the experi-
ments of Mr. Kosegarten.   By distilling the nitric acid
several times from this substance, it acquires all the pro-
perties of an acid which crystallizes in parallelopipedons.
To obtain the camphoric acid, nothing more is required
than to distil the acid at several times from the camphor,
and in a large quantity.   Mr. Kosegarten distilled the ni-
tric acid eight times from camphor, and obtained a salt
crystallized in parallelopipedons, which reddened syrup of
violets, and the tincture of turnsole.   Its taste is bitter;
and it differs from the oxalic acid in not precipitating lime
from the muriatic acid.

With potash it forms a salt which crystallizes in regu-
lar hexagons.

With soda it affords irregular crystals.

With ammoniac it forms crystalline masses, which ex-
hibit crystals in needles and in prisms.

With magnesia it produces a white pulverulent salt,
which may again be dissolved in water.

It dissolves copper, iron, bismuth, zinc, arsenic, and
cobalt.   The solution of iron affords a yellowish white
powder, which is insoluble.

This acid forms, with manganese, crystals whose
planes are parallel, and in some respects resemble
basaltes.

The camphoric acid, or rather the radical of this
acid, exists in several vegetables; since camphor may
be extracted from the oils of thyme, of cinnamon, of tur-
pentine, of mint, of feverfew, of sassafras, &c.   Mr.
Dehne has obtained it from the pasque flower or pulsatil-
la ; and Cartheuser has indicated several other plants which
contain it.

Alcohol readily dissolves it, and it may be precipi-
tated by water alone : this solution is known in phar-

macy by the name of Camphorated Spirit of Wine,
or Camphorated Brandy, when brandy is the sol-
vent.

The fixed and volatile oils likewise dissolve each
other by the assistance of heat ; the solutions let fall
crystals in vegetation, similar to those which are form-
ed in the solutions of sal-ammoniac, composed of very
fine filaments adhering to a middle part. This obser-
vation was made by Mr. Romieu. Acad. des Sciences,
1756.

Camphor is one of the best remedies which the art of
medicine possesses. When applied to inflammatory tu-
mours, it is resolvent ; and, internally taken, it is antis-
pasmodic, especially when dissolved in brandy. It is
given in Germany and in England in the dose of several
drams per day ; but in France our timid physicians do
not prescribe it in a larger dose than a few grains. It
mitigates heat in the urinary passage. It is given tritu-
rated with yolk of egg, sugar, &c.

It has likewise been supposed that its smell destroyed
or drove away moths, and other insects which feed upon
cloth, &c.

ARTICLE III.

Concerning Resins.

The name of Resin is used to denote inflammable sub-
stances soluble in alcohol, usually affording much soot
by their combustion ; they are likewise soluble in oils,
but not all in water.

All the resins appear to be nothing else but oils
rendered concrete by their combination with oxigene.
The exposure of these to the open air, and the decom-
position of acids applied to them, evidently prove this
conclusion.

Resins in general are less sweet than the balsams.
They afford more volatile oil, but no acid, by distil-
lation.

There are some among the known resins which are very pure, and perfectly soluble in alcohol, such as the balm of Mecca and of Copahu, turpentines, tacamahaca, elemi : others are less pure, and contain a small portion of extract, which renders them not totally soluble in alcohol ; such are mastic, sandarach, guaiacum, labdanum, and dragon's blood.

1. The balsam of Mecca is a fluid juice which becomes thick and brown by age. It flows from incisions made in the amyris opobalsamum. It is known by the different names of Balm of Judea, of Egypt, of Grand Cairo, of Syria, of Constantinople, &c.

Its smell is strong, and inclining to that of lemons; its taste is bitter and aromatic.

This balsam, distilled by the heat of boiling water, affords much volatile oil.

It is balsamic ; and is given incorporated with sugar, or mixed with the yolk of egg. It is aromatic, vulnerary, and healing.

2. The balsam of Copahu flows from a tree called Copaiba, in South America, near Tolu. It affords the same products, and possesses the same virtues, as the foregoing.

3. The turpentine of Chios flows from the turpentine tree, which affords the pistachios. It is fluid, and of a yellowish white colour inclining to blue.

This plant grows in Cyprus, at Chios, and is common in the south of France. The turpentine is obtained only from the trunk and large branches. Incisions are made first at the lower parts of the tree, and afterwards by degrees higher up.

This turpentine distilled on the water-bath, without addition, affords a very white, very limpid, and very fragrant volatile oil : a more ponderous oil may be extracted at the heat of boiling water ; and the residue, which is called Boiled Turpentine, affords by distillation, in the reverberatory furnace a weak acid, a small quantity of brown consistent oil, and much coal.

The turpentine of Chios is very rare in commerce. Venice turpentine is extracted from the larix : its colour

is a bright yellow, its consistence limpid, its smell strong
and aromatic, and its taste bitter.

The tree which affords it is that which affords manna.
Holes are bored during the summer near the bottom of
the trunks of these trees, into which small gutters or tubes
are inserted, to convey the juice into vessels intended to
receive it.   The resin is obtained only from trees in full
vigour; the old trees very often have considerable depo-
sitions of resin in their trunks.

This turpentine affords the same principles as that of
Chios.

It is used in medicine as a detergent for ulcers in the
lungs, kidneys, &c. either incorporated with sugar, or
mixed with the yolk of an egg, to render it more misci-
ble with aqueous potions.   The soap of Starkey, which
we have spoken of under the article of Volatile Oils, is
made with this turpentine.

The resin known in commerce by the name of
Strasburgh Turpentine, is a resinous juice of the con-
sistence of a fixed oil, of a yellowish white colour, a bit-
ter taste, and a more agreeable smell than the preceding
resins.

It flows from the yew-leaved fir, which is very com-
mon in the mountains of Switzerland.   This resin is
collected in blisters, which appear beneath the bark in the
strong heats of summer.   The peasants pierce these ve-
sicles with the point of a small horn, which becomes filled
with the juice, and is from time to time emptied into a
larger vessel.

The balm of Canada differs from the turpentine
of the fir in its smell only, which is more pleasant.
It is obtained from a species of fir which grows in Ca-
nada.

Oil of turpentine is more particularly used in the arts.
It is the great solvent for all resins; and, as it evaporates,
it leaves them applied to the surface of bodies on which
the mixture has been spread.   As resins are the basis of
all varnishes, alcohol and oil of turpentine must be the ve-
hicles or solvents.

4. Pitch is a resinous juice, of a yellow colour,
more or less inclining to brown.   It is afforded by a fir

named Picea or Epicea.   Incisions are made through
the bark; and the wound is renewed from time to time,
as the lips become callous.   A vigorous tree often affords
forty pounds.

Pitch melted, and expressed through bags of cloth, is
rendered purer.   It is packed in barrels, by the name of
White Pitch, or Burgundy Pitch.

White pitch mixed with lampblack, forms black
pitch.

White pitch kept in fusion becomes dry.   The desicca-
tion may be facilitated with vinegar, and leaving it for a
time over the fire.   It then becomes very dry, and is cal-
led Colophony.

Lampblack is the soot of burned pitch.   It is likewise
prepared by collecting the soot of pit-coal.

5. Galipot is a concrete resinous juice, of a yellowish
white colour and strong smell.   This juice comes from
Guienne, where it is afforded by two species of pine, the
pinus maritima major, et minor.

When these trees have acquired a certain size, a hole
or notch is cut through the bark, near the bottom of
the trunk.   The resin issues out, and flows into ves-
sels placed beneath to receive it.   Care is taken
to keep the wound open, and to renew it.   The
resin flows during the summer; but that which issues
out during the spring, autumn, and winter, dries against
the tree.

The pine likewise affords tar, and the oil called *huile
de Cade.*   For this purpose the wood of the trunk, bran-
ches, and roots, is heaped together, and covered with turf,
over which a fire is lighted, as if to convert them into
charcoal.   The oil which is disengaged, not being at li-
berty to escape, falls to the bottom into a channel or gut-
ter, which conveys it into a tub.   The most fluid part is
sold under the name of *huile de Cade*; and the thicker
part is the tar used for paying or painting the parts of
shipping and other vessels.

The combination of several resins, coloured by cin-
nabar and minium, forms sealing-wax.   To make the
wax, take half an ounce of gum lac, two drams of
turpentine, the same quantity of colophony, one dram
of cinnabar, and the same quantity of minium.   The

lac and the colophony are to be first fused, after which the turpentine is to be added, and lastly the colouring matters.

6. Mastic has the form of white tears of a farinaceous appearance, having little smell, and a bitter astringent taste.   Mastic flows naturally from the tree, but its produce is accelerated by incisions.   The lesser turpentine tree, and the lentiscus, afford that which is met with in commerce.

Mastic affords no volatile oil when distilled with water. It is almost totally soluble in alcohol.

This resin is used in fumigations.   It is chewed to strengthen the gums; and it forms the basis of several drying varnishes.

7. Sandarach is a concrete resinous juice, in dry white transparent tears, of a bitter and astringent taste.   It is obtained from most species of the juniper, and is fouud between the bark and the wood.

Sandarach is almost totally soluble in alcohol, with which it forms a very white varnish, that dries speedily. For this reason, the resin itself is known by us under the name of Varnish *(vernis.)*

1. Labdanum is a black resinous juice, dry and friable, of a strong smell, and a disagreeable aromatic taste.   It transudes from the leaves and branches of a kind of cistus, which grows in the island of Candia.   Tournefort, in his Voyage to the Levant, informs us that when the air is dry, and the resin issues out of the pores of the cistus, the peasants strike all the parts of these trees with a kind of whip, made of several thongs of leather, fixed to the end of a staff.   The juice adheres to the leather, and is cleared off with a knife.   This is pure labdanum, and is very rare.   That which is known by the name of *labdanum in tortis*, is mixed with a very fine ferruginous sand, for the purpose of increasing its weight.

9. Dragon's blood is a resin of a deep red in the mass, but brighter when in powder.   It has neither taste nor smell.

It is obtained from the *drakena*, in the Canary islands, from which it flows in tears during the dog-days.   It is also obtained from the ptero-carpus draco.   The parts are exposed to the vapour of hot-water; the juice issues

out in drops, which are collected and wrapped up in the leaves of reeds.

The dragon's blood of the shops, which has the form of flattened orbicular loaves, is a composition of various gums, to which this form is given, after they have been coloured with a small quantity of dragon's blood.

Dragon's blood is soluble in alcohol: the solution is red: the resin itself may be precipitated of the same colour.

This resin is used in medicine as an astringent.

ARTICLE IV.

Concerning Balsams.

Some authors define balsams to be fluid inflamma-ble substances; but there are some which are dry. Others again give this name to the most fragrant among the resins. M. Bucquet has confined this denomination to such resins only as have a sweet flavour, capable of being communicated to water; and which more especially contain fragrant acid and concrete salts, which may be se-parated by decoction or sublimation. It appears there-fore that these substances contain a principle not found in resins, which combining with oxigene, forms an acid; while the oil, saturated with the same air, forms the resin. This acid salt is soluble in water and alcohol. As the chemical analysis points out a sufficiently striking differ-ence between balsams and resins, we think it proper to treat them separately.

The substances called Balsams are therefore resins united with a concrete acid salt. We are acquainted with three principal kinds; viz. benzoin, the balsam of Tolu, and the storax calamita.

1. Benzoin is a coagulated juice, of a pleasant fragrant smell, which becomes stronger by friction and heat.

Two varieties of this substance are known; the ben-zoë amygdaloides, and the common benzoin. The first

is composed of the most beautiful tears of this balsam,
connected together by a gluten of the same nature, but
browner, and of the aspect of nutmegs in its fracture.
The second is merely the juice itself, without any mixture
of these fine and very pure tears. It comes to us from
the kingdom of Siam, and the island of Sumatra; but
we do not know the tree that affords it.*

Benzoin, laid upon hot coals, fuses, speedily takes fire,
and emits a strong aromatic smell. But if it be merely
heated, without setting it on fire, it swells up, and emits
a more pleasant though less powerful smell.

Benzoin pounded, and boiled in water, affords an acid
salt, which crystallizes in long needles by cooling. This
salt may also be extracted by sublimation. It rises by a
degree of heat even less than that which is required to
raise the oil of benzoin; and this is the substance called
Flowers of Benzoin, or the Sublimed Acid of Benzoin.
Neither of these processes are economical; and in the
preparation of these articles, in the large way, I begin by
distilling the benzoin, and cause all the products to pass
confounded together into a capacious receiver. I then
boil the product in water, and by this means I obtain a
much greater quantity of the salt of benzoin: because,
in this state, the water attacks and dissolves the whole
contents; whereas the most accurate trituration will not
produce the same effect.

The sublimed acid of benzoin has a very penetrating
aromatic smell, which excites coughing; more especially
if the subliming vessels be opened while yet hot. It red-
dens the syrup of violets, and effervesces with the alka-
line carbonates. It unites with earths, alkalis and metals,
and forms benzoates, of which Bergmann and Scheele
have given us some account.†

* For a drawing and description of this tree, consult Dryander,
in the Phil. Trans. vol. lxxvii. No. 31.

† Benzoic acid exists in the urine of horses.—These animals are
said to be diseased when they secrete it—for a sound horse gives lit-
tle or none. It does not arise from their food, for it cannot be de-
tected in straw or oats. Sometimes it is combined with soda.*—
Am. Ed.

* Tilloch's Philos. Mag. vol. xvi, p. 151.

Alcohol dissolves benzoin totally, without leaving any residue but such foreign impurities as the balsam may happen to contain. It may be precipitated by the addition of water; and then constitutes the opaque fluid called Lac Virginale.

Benzoin is used as an aromatic in medicine: but it is seldom used in substance, because of its sparing solubility: its tincture, and volatile acid, are used. The latter is a good incisive medicine to be administered in pituitous obstructions of the lungs, the kidneys, &c. It is given in extracts, or dissolved in water.

Benzoin is employed in fumigations for indolent tumours. The oil is likewise an excellent resolvent. It is applied by friction to members affected with cold rheumatic and paralytic disorders.

2. The balsam of Tolu, of Peru, or of Carthagena, has a mild and pleasant smell.

It is met with in commerce in two different forms; either in shells, or in the fluid state. The cocoa is softened by boiling water, and the balsam flows out in the fluid form.

The tree which affords it, is the Toluifera of Linnæus. It grows in South America, in the district called Tolu, between Carthagena and Nombre de Dios.

The fluid balsam affords much volatile oil when distilled by the heat of boiling water.

An acid salt may be extracted from this balsam, which greatly resembles that of benzoin, and may be obtained by the same processes; but this sublimed salt is commonly brown, because it is soiled by a portion of the balsam, which rises with a less heat than benzoin does.

This balsam is soluble in alcohol, and may be precipitated by the addition of water.

It is much used in medicine, as an aromatic, vulnerary, and antiputrescent remedy. It is administered either triturated with sugar, or mixed with some extract. A syrup is prepared from it by digesting it in a gentle heat with sugar; or by dissolving it in alcohol, adding sugar, and suffering the alcohol to dissipate spontaneously.

It is falsified by macerating the distilled oil of benzoin upon the buds of the balm scented poplar, and adding a small quantity of the natural balsam.

Storax or styrax calamita is a juice of a very strong but pleasant smell. Two varieties are known in commerce : the one in reddish clean tears ; the other in masses of a blackish red colour, soft and fatty.

The plant which affords it is called the oriental liquid amber. It has been long supposed to be the styrax folio mali cotonæi C. B. which is known in Provence, in the wood of La Chatreuse de Montrieu, by the name of Alibousier ; and, according to Duhamel, affords a very odorant juice, which he took for storax.

Its habitudes during analysis are the same as the preceding, and it exhibits the same phenomena.

It was formerly brought to us in canes or reeds, whence its name of storax calamita.

These three balsams form the base of those fragrant pastils which are burned in the chambers of the sick, to conceal or disguise bad smells. These balsams are made into masses by means of gum ; with the addition of charcoal and the nitrate of potash, to facilitate combustion.

ARTICLE V.

Concerning Gum Resins.

The gum resins are a natural mixture of extract and resin. They seldom flow naturally from plants, but issue out from incisions made for that purpose. They are sometimes white, as in the tithymalus and the fig-tree ; sometimes yellow, as in the chelidonium : so that we may consider these substances as true emulsions, whose constituent principles vary in their proportions.

The gum resins are partly soluble in water, and partly in alcohol.

One character of gum resins is, that they render water turbid in which they are boiled.

This class is sufficiently numerous: but we shall only treat of the principal species, and more especially those which are used in medicine.

1. Olibanum, or frankincense, is a gum resin, in tears of a yellowish white colour and transparent. Two kinds

are known in trade : the male incense, in small very pure tears ; and the female incense, in large and impure tears.

The tree which affords it is not known.   Some authors suppose it to be the cedar with cypress leaves.

Olibanum contains three parts of resinous matter, and one of extract.   When it is boiled in water, the solution is white and turbid, like that of all the juices of this class. When it is fresh, it affords a quantity of volatile oil.

Olibanum is used in medicine as a resolvent.   But its chief use is in our temples, where it has been adopted as one of the instruments of worship of the Divinity.

It is used in hospitals, to disguise the smell of the pu-trid air which is exhaled.   M. Achard has proved that this proceeding has no other effect than that of deceiving the sense of smelling.

2. Scammony is of a blackish grey colour, a bitter and acrid taste, and a strong nauseous smell.

Two varieties are met with in commerce ; one of which comes from Aleppo, and the other from Smyrna.   The first is paler, lighter, and more pure ; the second is black, heavy, and mixed with foreign substances.

It is extracted from the convolvulus scammonia, prin-cipally from the root.   For this purpose incisions are made at the head of the root.   It is collected in muscle shells.   But most of that met with in trade is obtained from the roots by expression.

From the results of the analysis of Geoffroy and Car-theuser, it appears that the proportion of the component parts varies in the different specimens examined.   The latter obtained near one half of extract, whereas the for-mer only one sixth.

Scammony is used in medicine as a purgative, in the dose of several grains.   When triturated with sugar and almonds, it forms a very agreeable purgative emulsion.   When softened by a mixture of the juice of liquorice, or of wild quinces, it forms the diagre-dium.

3. Gum guttæ has a reddish yellow colour : it has no smell, but its taste is acrid and caustic.   Gum guttæ was brought to Clusius in 1630.   It comes from the kingdom of Siam, from China, and from the island of

Ceylon, in cylinders of various sizes. The tree which affords it is called Coddam Pulli. Herman reports, from his own observation as an eye witness, that a milky and yellowish juice flows from incisions made in these trees; that this juice becomes thick by the heat of the sun; and that, when it is in a state fit to be handled, it is formed into large globular masses.

Geoffroy has extracted five sixths of resin from gum guttæ. Cartheuser has ascribed to it more extractive than resinous matter.

Gum guttæ is sometimes used as a purgative, in a dose of a few grains. But the principal use of this substance is in painting, where it is recommended by the beauty of its colour.

4. Asa fœtida is met with in tears of a yellowish white colour; but most commonly in the form of loaves formed by the aggregation of a number of the tears. It has an acrid and bitter taste, and its smell is one of the most disagreeable.

The plant which affords it is called Ferula Asa Fœtida.

This plant grows in Persia: and the juice of its root is obtained by expression, according to Kæmpfer. It is fluid and white when it issues from the plant, and it emits an abominable smell when recent. This juice loses its smell, and becomes coloured, as it dries. But it still preserves smell enough to entitle it to the name of Stercus Diaboli.

The Indians find its flavour agreeable; they use it for seasoning, and call it the *food of the gods :* a proof which evinces, beyond every argument, that tastes must not be disputed.

Cartheuser found it to contain one third of resin.

It is a solvent and discutient remedy; and more particularly valuable as a most powerful antihysteric.

5. Aloes is a juice of a red brown colour, and very considerable bitterness. Three species are distinguished —the soccotrine aloes, the hepatic aloes, and the coballine aloes; they differ only in their degree of purity. M. de Jussieu, who saw these three varieties prepared at Morviedro in Spain, assures us that they are all obtained from

the aloë vulgaris. The first variety is obtained by making incisions in the leaves. Time is allowed for its impurities to subside perfectly. The fluid is then de-canted from the dregs, and left to become thick; after which it is put into leathern sacks for sale, under the name of Soccotrine aloes. A juice of the same nature is ob-tained by expression from the same leaves which when clarified in the same manner, forms the hepatic aloes : and the coballine aloes is obtained by a stronger pressure.

The Soccotrine aloes contains no more than one eighth of resin, according to Boulduc. The hepatic aloes con-tains half its weight.

Aloes is very much used in medicine as a purgative, tonic, alterative, and vermifuge.

6. Gum ammoniac is sometimes met with in small tears, white within, and yellow without. But they are often united in the mass, resembling the benzoë amyg-daloides.

Its smell is fetid ; and its taste acrid, bitter, and rather nauseous.

This juice comes from the deserts of Africa, and the plant which affords it is unknown : it is presumed to be of the class of umbelliferous plants, from the figure of the seeds found in it.

Gum ammoniac is very much used in medicine. It is a very good alterative ; and is given in pills, incorporated with sugar, or in some extract. It may even be dissolv-ed or diffused in water ; this liquid becomes turbid, and of a yellowish white. Gum ammoniac enters into the composition of all discussive plasters.

Concerning Caoutchouc, or Elastic Gum.

Elastic gum is one of those substances which it is difficult to class. It burns like resins ; but its softness, its elasticity, and its insolubility in the menstruums which usually dissolve resins, do not allow us to class it among those bodies.

The tree which affords it is known by the name of Seringa by the Indians of Para. The inhabitants of the province of Esmeraldas, a province of Quito, call

it Hhava; and those of the province of Mainas Cacut-
chouc.

Mr. Richard has proved that this tree is of the family
of the euphorbia; and Mr. Dorthes has observed, that
the *coccus* which are covered with a down that resembles
small straws, were covered with a gum very much
resembling the elastic gum. These insects feed on the
euphorbium; but those which come from other situati-
ons afford the same juice.

We are indebted to Mr. Condamine for an account,
and accurate details, concerning this tree. (Acad. des
Sciences, 1751.) This academician informs us, after
M. Fresneau, engineer at Cayenne, that the caoutchouc
is a very lofty tree. Incisions are made in the bark;
and the white juice, which flows out in a more or less
liquid state, is received in a vessel placed for that pur-
pose. This is applied in successive coatings upon a
mould of clay, and dried by the fire, or in the sun.* All
sorts of designs are traced upon it while soft; and when
it is dry, the clay mould is crushed, and the pieces
shaken out.†

This gum is very elastic, and capable of great exten-
sion.

When elastic gum is exposed to the fire, it be-
comes soft, swells up, and burns with a white flame.
It is used for illumination, instead of candles at Cay-
enne.

It is not at all soluble either in water or alcohol. But
Macquer has assured us that ether is its true solvent; and
upon this property he has instituted the art of making

* It is said that twenty seven coats of the milk are applied to
the mould.

† Many trees, natives of the torrid zone, yield a milky juice, of
the same nature as the Caoutchouc, as Artocarpus integrifolia or
common jack tree; Ficus indica et religiosus; Hippomane biglan-
dia, and Cecropia peltata.

The editor has examined a great variety of the milky plants of
the United States, and extracted gum elastic from many of them,
as Apocynum Cannabinum or Indian Hemp, Sonchus Floridanus, or
Sow Thistle, Asclepias Syriaca, or Syrian Swallow wort, Euphorbia
Picta or Painted Spunge, &c.—*Am. Ed.*

bougies for chirurgical uses of elastic gum, by applying
this solution upon a mould of wax till it is of the requi-
site thickness.*

Mr. Berniard, to whom we are indebted for import-

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* The liquid of Gum elastic is drawn from a tree by incisions,
and thickens in the manner of resinous juices.   It cannot be pro-
cured in its original state of fluidity, to give it all the the forms un-
der which it might be useful to us.   It grows in Brazil, and the ne-
cessity of parting the line, is an obstacle to the juice arriving in a
proper state for our purposes, as it is decomposed by heat, in the
same manner as milk, exhaling a very fœtid odor, and having no lon-
ger its original properties.   Sir Joseph Banks, President of the
Royal Society of London, once had a bottle of it in its original state,
but which after a little time became decomposed, since which he
has not been able to procure any more from Lisbon, although he
has offered fifty guineas for a second bottle

Tubes of gum elastic are made by cutting a bottle circularly in a
spiral slip of a few lines in breadth.   It is an easy matter to cut a
a bottle in such a manner, as to form a single long slip.

The whole slip is then to be plunged into ether, until it is suffi-
ciently softened, which it will be in half an hour.   Mr. Grossart, the
the author of an excellent memoir on the method of making instru-
ments of Gum elastic, says that there is a great diversity in the man-
ner, in which different sorts of vitriolic ether act, and of which the
cause is not known.

The ether should be well washed in water, and contain no vitriolic
acid.

The slip being taken out one of the extremities is to be taken
hold of, and rolled first upon itself at the bottom of the tube, pressing
it ; then the rolling is to be continued, mounting spirally along the
mould, and taking care to lay over and compress with the hand every
edge, one against the other, so that there may not be any vacant space,
and that all the edges may join exactly.   The whole is then to be
bound hard with a tape an inch wide, taking care to turn it the same
way with the slip of elastic gum.   This tape is to be tied over with
pack-thread, so that by every turn of the pack-thread, joining ano-
ther, an equal pressure is given to every part : it is then left to dry,
and the tube is made.

It is easy to draw off the tube ; if it sticks, it may be plunged in hot
water.

Tubes may likewise be made with the oil of turpentine and
lavender.

He likewise tells us, that he has made the tubes by boiling the
gum elastic in water.   When water is used, after the tube is co-
vered with packthread, it is to be kept some hours in boiling
water

Always avoid placing the exterior slips one upon another.—*Am.*
Ed.

ant observations upon this substance, found only the nitric ether to dissolve elastic gum. Very pure sulphuric ether did not perceptibly act upon it.

If elastic gum be put in contact with a volatile oil, such as that of turpentine, or even if it be exposed to the vapour of that fluid, it swells, softens, and becomes very pasty. It may then be spread upon paper, or applied as a varnish to cloth; but this covering preserves its adhesive quality, and does not lose it for a long time. The mixture of volatile oil and alcohol forms a better solvent than the pure oil, and the varnish dries more speedily.

Mr. Berniard has concluded from his experiments that the elastic gum, is a fat oil coloured by a matter soluble in alcohol, and soiled by the smoke to which the gum is exposed in drying.

If linseed oil be rendered very drying by digesting it upon the oxides of lead, and it be afterwards applied with a small brush upon any surface, and dried by the sun or in the smoke, it affords a pellicle of a considerable degree of firmness, evidently transparent, burning like the elastic gum, and wonderfully elastic and extensible. If this very drying oil be left in a wide shallow vessel, the surface becomes thick, and forms a membrane which has the greatest analogy with the elastic gum. A pound of this oil spread upon a stone, and exposed to the air for six or seven months, acquired almost all the properties of elastic gum. It was used to make catheters and bougies; was applied to varnish balloons, &c

Some gum resins are cleared by art of their extractive principle, for the purpose of applying them to various uses. Such is the intention of the process used to make bird-lime. This is made from different substances, as the berries of misletoe, the fruit of the sebesten, &c. But the best is made of the hollyoak. These trees are peeled in the month of June or July: the outer bark is rejected, and the second is boiled in spring water for seven or eight hours. It is then made into masses, which are buried in the ground, and covered with stones, for several layers one over the other. After having previously drained off the moisture, they are suffered to fer-

ment for fifteen days, until the matter has acquired the adhesive consistence of paste.   The mass is then beaten till it becomes capable of being wrought with the hands, or kneaded; after which it is washed in a running stream.   Lastly, it is placed for three or four days in another vessel, that it may throw up its skum or impuri. ties; in which last state it is put into proper vessels, and kept for use.

The following composition is likewise made use of under the name of bird-lime.   Take one pound of bird-lime, one pound of goose-grease; add to this one ounce of vinegar, half an ounce of oil, and the same quantity of turpentine.   Boil the mixture for several minutes, and heat the mass when you are desirous of using it as a ce-ment.   It may be prevented from freezing in winter, by adding a small quantity of petroleum.

Concerning Varnish.

The Pere d'Incarville has informed us that the tree which affords the varnish of China is called Tsi-chou by the Chinese.   This tree is propagated by off-sets.   When the cultivator is desirous of planting this, he takes a branch, which he wraps up in a mass of earth, by means of flax. Care is taken to moisten this earth; the branch pushes out roots, and is then pruned and transplanted.   This tree grows to the size of a man's leg.

This varnish is drawn in spring.   If it be a cultivated tree, it affords three gatherings.   It is extracted by inci-sions made in the spring; and when the varnish, which is received. in shells, does not flow, several hog's bristles, moistened with water or spittle, are introduced into the wound, and cause it to run.   When the tree is exhaust-ed, the upper part of it is wrapped in straw, which is set on fire, and causes the varnish to precipitate to the bottom of the tree, where it flows out of perforations made for that purpose.

Those who collect the varnish set out before day-break, and place their shells beneath the apertures.   The shells are not left longer than three hours in their place, because the heat of the sun would evaporate the varnish.

The varnish emits a smell which the workmen are very careful to avoid respiring. It produces an effect which they call the bud of the varnish.

When the varnish issues from the tree, it resembles pitch. By exposure to the air it naturally becomes coloured, and is at last of a beautiful black.

The juice which flows from incisions made in the trunk and branches of the rhus toxicodendron, possesses the same properties. The tree that grows in our climates affords a white milky fluid, which becomes black and thick by the contact of the air; its colour is the most beautiful black: and it would be easy to introduce this valuable species of industry into the kingdom, because the tree grows wonderfully well in all climates, and resists the cold of the winter.

To make the varnish bright, it is evaporated by the sun; and a body is given to it with hog's gall, and the sulphate of iron, or martial vitriol.

The Chinese use the oil of tea, which they render drying by boiling it with orpiment, realgar, and arsenic.

The varnishes most used in the arts have all of them the resins for their base; and the fundamental facts in this valuable art are reducible to the following principles.

To varnish any substance, consists in applying upon its surface a covering of such a nature, as shall defend it from the influence of the air, and give it a shining appearance.

A coat of varnish ought therefore to possess the following properties:—1. It must exclude the action of air; because wood and metals are varnished to defend them from decay and rust. 2. It must resist water; for otherwise the effect of the varnish could not be permanent. 3. It ought not to alter such colours as are intended to be preserved by this means.

It is necessary therefore that a varnish should be easily extended or spread over the surface, without leaving pores or cavities; that it should not crack or scale; and that it should resist water. Now resins are the only bodies that possess these properties.

Resins consequently must be used as the bases of varnish. The question which of course presents itself must then be, how to dispose them for this use; and for this

purpose they must be dissolved, as minutely divided as possible, and combined in such a manner that the imperfections of those which might be disposed to scale, may be corrected by others.

Resins may be dissolved by three agents—1. By fixed oil. 2. By volatile oil. 3. By alcohol. And accordingly we have three kinds of varnish : the fat or oily varnish, essential varnish, and spirit varnish.

Before a resin is dissolved in a fixed oil, it is necessary to render the oil drying. For this purpose the oil is boiled with metallic oxides ; in which operation the mucilage of the oil combines with the metal, while the oil itself unites with the oxigene of the oxide. To accelerate the drying of this varnish, it is necessary to add oil of turpentine.

The essential varnishes consist of a solution of resin in oil of turpentine. The varnish being applied, the essential oil flies off, and leaves the resin. This is used only for paintings.

When resins are dissolved in alcohol, the varnish dries very speedily, and is subject to crack ; but this fault is corrected by adding a small quantity of turpentine to the mixture, which renders it brighter, and less brittle when dry.

The coloured resins or gums, such as gum guttæ, dragon's blood, &c. are used to colour varnishes.

To give lustre to the varnish after it is laid on, it is rubbed with pounded pumice stone and water ; which being dried with a cloth, the work is afterwards rubbed with an oiled rag and tripoli. The surface is last of all cleaned with soft linen cloths, cleared of all greasiness with powder of starch, and rubbed bright with the palm of the hand.

ARTICLE VI.

Concerning the Fecula of Vegetables.

The fecula appears to be only a slight alteration of mucilage ; for it differs from that substance in no other respect than in being insoluble in cold water, in which li-

quid it falls with wonderful quickness. If it be put into hot water, it forms a mucilage, and resumes all its characters. It seems that the fecula is simply a mucilage deprived of caloric. In fact, a young plant is all mucilage ; the old plants and fruits afford little fecula, because the heat is stronger in young than in old plants, according to Dr. Hunter.

There are few plants which do not contain fecula. Mr. Parmentier has given us a list of all those which afford it, in his experiments. (See his Recherches sur les Vegetaux Nourissans.) But the seeds of gramineous and leguminous vegetables, as well as the roots, which botanists call Tuberose, contain it most plentifully.

Nothing more is required, in order to extract the fecula, than to bruise or grind the plant in water ; and the fecula, which is at first suspended in that fluid, soon falls to the bottom. We shall not in this place attend to any other feculæ but such as are used in the arts or in medicine. Such are those of bryony, of potatoes, cassava, sago, salep, starch, &c.*

1. The fecula of bryony is extracted from the root of that plant. The bark is first taken off from the root, which is then rasped, and submitted to the press. The juice which flows out by expression is rendered white and opaque by a fecula which subsides. The liquid is then decanted off, and the fecula dried. It is strongly purgative, on account of a portion of extract which it retains ; but it may be deprived of its purgative virtue by careful washing in water. If water be poured on the marc which remains beneath the press, a large quantity is obtained which is not purgative, because the extractive matter was forced out by the first operation. Mr. Baumé has proposed to substitute this fecula instead of starch. The fecula is afforded by similar treatment of the roots of cornflag and arum.

2. That which is generally known by the name of Potatoe Flour, is nothing but the fecula of this root obtained by ordinary and easy processes. The root being well

* The editor has obtained starch in large quantities, and of the best quality, from the seeds of the æsculus pavia, horse chesnut or buck eye, a native of this country.—*Am. Ed.*

washed, it is pounded or crushed in such a manner as perfectly to destroy its texture. The pulp is then put into a sieve, and water poured on it, which carries off the fecula, and deposites it at the bottom of the receiving vessel. The water, which is coloured by extractive matter, and part of the parenchyma that remains suspended, is decanted off, and the deposition is washed several times. The colour of the fecula grows whiter as it dries; a. when dry it is very white and fine.

As this fecula has become an article of common use for some time past, several instruments have been contrived which are more or less suited to bruise the potatoes. Rasps have been proposed turning in cylinders, mills armed with points of iron, &c.

3. The cassava of the Americans is extracted from the roots of the manioc. This plant contains an acrid and very dangerous poison, of which it must be very carefully deprived. The Americans take the fresh root of manioc, which they peel, rasp, and enclose in a bag or sack formed of rushes, and of a very open texture. This bag is suspended from a staff; and a very heavy vessel is fastened to its lower part, which draws the bag down, so as in some measure to compress the root, at the same time that it receives the juice as it flows out. The juice is a most dreadful poison. When the root is well cleared of the juice, it is put into the same bags, and exposed to dry in the smoke. The sifted root is called Cassava. To convert it into food, it is spread out upon a hot brick or plate of iron, and when the surface which rests immediately on the brick is of a reddish brown colour, it is turned, to bake the other side; and in this state it forms what is called Cassava Bread.

The expressed juice carries with it the finest part of the fecula, which quickly subsides; and this fecula, known by the name of Mouchasse, is used to make pastry.

The poisonous extract which most of these roots that abound in fecula contain, ought to engage those who prepare them to be uncommonly attentive to the due management of the process. Without the most scrupulous care the most unhappy consequences may follow. It should always be recollected, in the prepara-

tion of these substances, that the poison is in contact with the food.

4. A fecula has likewise been appropriated to domestic uses which is extracted from the pith of several farinaceous palms, and is known by the name of Sago. This preparation is made in the Molucca Islands. The pith of middle aged palms is only used; for the young, as well as the old, affords very little fecula. This pith is mixed with water; and the fecula which is extracted, and renders the fluid white, is suffered to subside. When the fecula is dried, it forms small grains; which when reduced to powder, and mixed with warm water, affords a very nourishing pulp or mucilage.

M. Parmentier has proposed to make sago out of potatoes, in consequence of his idea that all feculæ are absolutely identical, and that this principle is one and the same in nature. For this purpose he proposes to add a spoonful of the fecula of potatoes gradually to a chopin, or half a pint, of hot water or milk, to be kept stirring over a gentle fire for half an hour. Sugar may be added, with aromatics or spices, such as cinnamon, lemon peel, saffron, orange-flower water, rose-water, &c.

The sago of potatoes may likewise be prepared with veal broth, chicken broth, or common broth. The preparation may be varied in a thousand ways, and it forms a very wholesome and nourishing food.

5. The bulbs of all the kinds of orchis may be used to make salep. All that is required to be done consists in depriving them of the extractive principle, and drying the residue, which becomes transparent by this operation.

In order to dry them more speedily, they are strung, and hung up; or otherwise it is thought sufficient to rub these bulbs in water either hot or cold, and to dry them in an oven. This last process was communicated to Dr. Percival by Mr. John Moult.

The fecula of salep, pulverized, and combined with water, forms a very nourishing jelly.

6. The fecula is likewise one of the constituent principles of the seeds of gramineous plants; and when these have been ground, and reduced into farina, nothing more

is required than to mix them with water, in order to pre-
cipitate the fecula. But another process for procuring it
is used in the arts : it consists in destroying by fermenta-
tion the extractive and glutinous part with which it is inti-
mately united; and in this consists the art of making
starch. The process of the starch-maker consists in fer-
menting grain, pollard, damaged flour, &c. in the acid
water which they call *eau sure*. When the fermentation
is ended, they take out the fecula, which is precipitated
to the bottom of the water, and put it into hair sacks.
Fresh water is poured upon this, which carries the finer
fecula with it ; and this being several times washed, con-
stitutes starch, cleared of every foreign principle.

There are likewise coloured feculæ, such as indigo,
which we shall treat of when we come to the article
Dying.

The uses of feculæ are very numerous.

1. They constitute a very nourishing food. because
the nutritive virtue of gramineous vegetables resides
in them. Those seeds which man has appropriated
for his food, contain much; and these feculæ form
a very nourishing jelly with hot water. It may be
seen, in the work of Mr. Parmentier, that this is truly
the most suitable nourishment for man. Some of these
are even entirely devoted to this purpose, such as the
cassava.

In the northern climates, the lichens form almost the
whole of the food of man, and such animals as are not
carnivorous: and these lichens, according to the expe-
riments of the Academy of Stockholm, afford an excel-
lent starch by simple grinding. The rein-deer, the stags,
and the other fallow cattle of the north of Europe,
subsist on the lichen rangiferinus. The Icelanders ob-
tain a very delicate gruel with fecula of the lichen Ice-
landicus.

2. Starch boiled in water, and coloured with a small
quantity of azure, forms a paste which is used to give
brightness, firmness, strength, and an agreeable colour,
to linen.

3. The feculæ are also used to make hair powder ;
and this consumption, which is prodigious, might be
supplied by starch made from less valuable plants than

the gramineous; and, if this were done, the objects of luxury would not enter into competition with our most immediate wants.

ARTICLE VII.

Concerning the Vegetable Gluten.

The glutinous principle, which, on account of its properties resembling those of animal substances, has been called the Vegeto-Animal Substance by some chemists, is more particularly obtained from gramineous vegetables. We are indebted to Beccari for the discovery of this substance; and the analysis of farinaceous substances has since been enriched with various important facts.

To make the analysis of any farina, the methods employed are such as are simple, and incapable of decomposing or altering any of its constituent parts. A paste is formed with the flour and water; and this is kneaded and wrought in the hands under water, till it no longer communicates any colour to that fluid. The substance which then remains in the hand is tenacious, ductile, and very elastic; and becomes more and more adhesive, in proportion as the water which it had imbibed flies off by evaporation. In this same operation the fecula falls to the bottom of the water; while the extractive matter remains in solution, and may be concentrated by evaporation of the fluid.

If the glutinous matter be stretched out, and then let go, it returns by spontaneous contraction to its original form. If it be left suspended, it becomes extended by its weight; and forms a very thin transparent membrane, which exhibits a kind of net work, resembling the texture of the membranes of animals.

M. Beccari has observed that the proportion of glutinous matter varies prodigiously in the several seeds of gramineous vegetables. Those of wheat contain the largest quantity; but he never found it in the garden

stuff or plants which are used by us for food. The quantity of glutinous matter also varies in the same kind of grain, according to the nature of the soil which has supported it. Humid situations afford scarcely any.

The glutinous matter emits a very characteristic animal smell. Its taste is insipid; it swells up on hot coals; becomes soon and perfectly dry in a dry air, or by a gentle heat; in which state it resembles glue, and breaks short like that substance. If in this state it be placed on burning coals it curls up, is agitated, and burns like an animal substance. By distillation it affords the carbonate of ammoniac.

Fresh made gluten, exposed to the air, readily putrefies; and when it has retained a small quantity of starch, this last passes to the acid fermentation, and retards the putrefaction of the gluten: and in this way a state is produced resembling that of cheese.

Water does not attack the glutinous part. If it be boiled with this fluid, it loses its extensibility and adhesive quality: a circumstance so much the more remarkable, as it was indebted to that fluid for the development of these qualities; for this principle existed without cohesion in the flour; and when it is deprived of water by drying, it also loses its elasticity and glutinous quality.

Alkalis dissolve it, by the assistance of a boiling heat. The solution is turbid; and deposites the gluten by the addition of acids, but deprived of its elasticity.

The nitric acid dissolves gluten with activity; and this acid at first emits the nitrogenous gas, as when treated with animal substances. This is followed by an emission of nitrous gas; and the residue, by evaporation, affords the oxalic acid in crystals.

The sulphuric and muriatic acids likewise dissolve it. M. Poulletier has observed, that salts with base of ammoniac may be obtained from these combinations dissolved in water or alcohol, and evaporated in the open air.

If the gluten be dissolved in the vegetable acids several times repeatedly, and precipitated by alkalis, it is restored to the state of fecula: and according

to Macquer, if vinegar be distilled by a gentle heat from this substance, it is reduced to the state of mucilage.

This substance therefore possesses a very decided animal character. It is to this gluten that wheat owes its property of making a good paste with water, and the facility with which it rises. Rouelle discovered a glutinous substance analogous to the present in the green fecula of plants, which afford ammoniac, and empyreumatic oil, by distillation. The expressed juice of the herbaceous plants likewise afforded it; such as that of borage, hemloc, sorrel, &c.

The gluten is sometimes destroyed by the fermentation of flour; by which change it is deprived of the wholesome qualities it before possessed, and is incapable of rising, and forming good bread.

Farina or flour, is therefore composed of three principles—the amylaceous principle, or starch; the saccharine principle; and the animal or glutinous principle. Whenever, therefore, by a suitable division, these principles are mixed together, and the fermentation is assisted by the known methods, each of these principles being capable of a different kind of fermentation, becomes deposed in its own peculiar manner. The saccharine principle undergoes the spirituous fermentation; the glutinous suffers the process of animal putrefaction; and the amylaceous is changed by the acid fermentation. The panary fermentation may therefore be considered as an union of these three different spontaneous changes. But as soon as the leading phenomena of the fermentation are well developed; and the principles, already well mixed and assimilated, have by this means suffered a change of their respective natures; the fermentation is stopped by baking: and the bread is found to be much lighter in consequence of these preliminary operations.

The art of making bread was not known at Rome until the year 585. The Roman armies, on their return from Macedonia, brought Grecian bakers into Italy. Before this time the Romans prepared their flour in no other way than by making it into pap or soft pudding;

for which reason the Romans, according to Pliny, were called Eaters of Pap.* See Aubery.

ARTICLE VIII.

Concerning Sugar.

Sugar is likewise a constituent part of vegetables, existing in considerable quantities in a number of plants. It is afforded by the maple, the birch, wheat, and turkey corn. Margraff obtained it from the roots of beet, red beet, skirret, parsnips, and dried grapes. The process of this chemist consisted in digesting these roots, rasped or finely divided, in alcohol. This fluid dissolves the sugar; and leaves the extractive matter untouched, which falls to the bottom.

In Canada the inhabitants extract sugar from the maple (acer montanum candidum). At the commencement of spring they heap snow in the evening at the foot of the tree, in which they previously make apertures for the passage of the returning sap. Two hundred pounds of this juice afford by evaporation fifteen of a brownish sugar. The quantity prepared annually amounts to fifteen thousand weight.

The Indians likewise extract sugar from the pith of the bamboo.

But the sugar which is so universally used is afforded by the sugar cane (arundo saccharifera) which is raised in our colonies. When this plant is ripe, it is cut down, and crushed by passing it between iron cylinders, placed perpendicularly, and moved by water or animal strength. The juice which flows out by this strong pressure is received in a shallow trough placed beneath the cylinder. This juice is called *vesou ;* and the cane, after having undergone this pressure, is called *begasse.*† The juice is

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* Pulte autem, non pane, vixisse longo tempore Romanos manifestum, quonium inde et Pulmentaria hodieque dicuntur. Plin. Hist. Nat. lib. xviii. cap. viii. et xi.—The date is 580 ab urbe conditâ. T.

† These are the names in the French sugar colonies. I do not find the corresponding terms in any of our writers. T.

more or less saccharine, according to the nature of the soil on which the cane has grown, and the weather that has predominated during its growth. It is aqueous when the soil or the weather has been humid; and in contrary circumstances it is thick and glutinous.

The juice of the cane is conveyed into boilers, where it is boiled with wood-ashes and lime. It is subjected to the same operation in three several boilers, care being taken to remove the skum as it rises. In this state it is called Syrup; and is again boiled with lime and alum till it is sufficiently concentrated, when it is poured into a vessel called the Cooler. In this vessel it is agitated with wooden stirrers, which break the crust as it forms on the surface. It is afterwards poured into casks, to accelerate its cooling; and, while it is still warm, it is conveyed into barrels standing upright over a cistern, and pierced through their bottom with several holes stopped with cane. The syrup which is not condensed filters through these canes into the cistern beneath; and leaves the sugar in the state called Coarse Sugar, or Muscovado. This sugar is yellow and fat, and is purified in the islands in the following manner:—The syrup is boiled, and poured into conical earthen vessels, having a small perforation at the apex, which is kept closed. Each cone, reversed on its apex, is supported in another earthen vessel. The syrup is stirred together, and then left to crystallize. At the end of fifteen or sixteen hours, the hole in the point of each cone is opened, that the impure syrup may run out. The base of these sugar-loaves is then taken out, and white pulverized sugar substituted in its stead; which being well pressed down, the whole is covered with clay, moistened with water. This water filters through the mass, carrying the syrup with it which was mixed with the sugar, but which by this management flows into a pot substituted in the place of the first. This second fluid is called Fine Syrup. Care is taken to moisten and keep the clay to a proper degree of softness, as it becomes dry. The sugar loaves are afterwards taken out, and dried in a stove for eight or ten days; after which they are pulverized, packed and exported to Europe, where they are still farther purified.

The operation of our sugar refiners consists in dissolv-
ing cassonade, or clayed sugar, in lime water.   Bullock's
blood is added, to promote the clarifying; and when the
liquor begins to boil, the heat is diminished, and the skum
carefully taken off.   It is in the next place concentrated
by a brisk heat; and, as it boils up, a small quantity of
butter is thrown in, to moderate its agitation.   When the
boiling is sufficiently effected, the fire is put out; the li-
quor is poured into moulds, and agitated, to mix the sy-
rup together with the grain sugar already formed.   When
the whole is cold, the moulds are opened, the loaves are
covered with moistened clay, which is renewed from time
to time till the sugar is well cleared from its syrup.   The
loaves being then taken out of the moulds, are carried to
a stove, where they are gradually heated to the fiftieth de-
gree of Reaumur.   They remain in this stove eight days,
after which they are wrapped in blue paper for sale.

The several syrups, treated by the same methods, af-
ford sugars of inferior qualities; and the last portion,
which no longer affords any crystals, is sold by the name
of Melasses.   The Spaniards use this melasses in the pre-
paration of sweet-meats.

A solution of sugar, much less concentrated than that
we have just been speaking of, lets fall by repose cry-
stals which affect the form of tetrahedral prisms, termi-
nated by dihedral summits, and known by the name of
Sugar Candy.

Sugar is very soluble in water; it swells up in the
fire, becomes black, and emits a peculiar smell, known
by the denomination of the smell of caromel.

Sugar is very much used for domestic purposes. It
constitutes the basis of syrups; and is used at our ta-
bles to disguise the sour taste of fruit and vegetable
juices.   It corrects the bitterness of coffee; and serves
as the vehicle in a great number of pharmaceutical pre-
parations.

Sugar is an excellent food; and it is merely an old
prejudice to suppose it produces worms in the bowels
of children.

It is now several years since the celebrated Bergmann
taught us to extract a peculiar acid from sugar, by
combining the oxigene of the nitric acid with one of

its constituent principles. The discovery of the acid of sugar was consigned in a thesis maintained at Upsal, the 13th of June 1776, by M. Arvidson, under the presidency of Bergmann.

To make the acid of sugar, or oxalic acid, nine parts of the nitric acid, with one of sugar, are put into a retort. A gentle heat is applied, to assist the action of the acid; which is rapidly decomposed upon the sugar, with the disengagement of a considerable quantity of nitrous gas. When the decomposition is completed, the distillation is continued on a sand bath, till the residue is sufficiently concentrated. It is then suffered to cool; and beautiful crystals are formed, which may be taken out, and have the figure of a tetrahedral prism terminating in a dihedral summit. By a farther concentration of the liquor in which the acid has crystallized more of these crystals may be obtained. These several products of crystals are then to be dissolved in pure water, and again crystallized, to separate them from any admixture of nitric acid that may adhere to them. This acid was formerly thought to be a modification of the nitric acid; and Bergmann was under the necessity of entering into a considerable detail of reasoning, to remove every doubt on the subject. But the knowledge we at present possess respecting the constituent principles of the nitric acid, and the great number of phenomena of this kind which it exhibits when made to act on various substances, render it unnecessary for us to enter into this consideration.

Cold water dissolves half its weight of this acid, and boiling water takes up its own weight.

This acid, combined with potash, forms a salt in prismatic hexahedral flattened rhomboidal crystals, terminating in dihedral summits. In order that crystallization may take place, it is necessary that one of the component parts should be in excess. This salt is very soluble in water.

The same acid forms with soda a salt which is very difficult to be brought to crystallize, and which converts syrup of violets to a green.

This acid, poured upon ammoniac, affords by a slight evaporation very beautiful tetrahedral prismatic crystals,

terminating in dihedral summits; one of whose faces is larger than the other, so that it occupies three angles of the extremity. See my Memoirs of Chemistry.—This salt is of great use in the analysis of mineral waters. It instantly shews the presence of any salt with basis of lime, because the oxalate of lime is insoluble in water.

The acid of sugar, or oxalic acid, attacks and dissolves most of the metals: but its action upon the oxides is stronger than upon the metals themselves ; and it takes the oxides from their true solvents. In this way it is that it precipitates the iron from a solution of the sulphate of iron, in a substance of the most beautiful yellow colour, which may be used in painting.

It precipitates copper in the form of a white powder, which becomes of a beautiful light green by drying.

Zinc is precipitated of a white colour.

This acid likewise precipitates mercury and silver, but not till after several hours standing.

An account of the combinations of this acid with various bases may be seen in Bergmann's treatise.

This acid may be extracted, by the action of nitric acid, from a number of vegetable substances, such as gums, honey, starch, gluten, or alcohol; and from several animal substances, according to the discovery of M. Berthollet, such as silk, wool, and lymph.

M. de Morveau, who has made a very valuable series of experiments on the acid of sugar, has proved that the whole of the sugar does not enter into the formation of the acid, but only one of its principles; and he affirms that it is an attenuated oil which exists in a variety of substances.

Since it has been ascertained, from the experiments of Scheele, Westrumb, Hermstadt, and others, that the acid of the salt of sorrel does not at all differ from that of sugar, they have been accordingly confounded under the same denomination ; and that salt which is known in commerce by the name of Salt of Sorrel, is an acidulous oxalate of potash.

The salt of sorrel is made in Switzerland, in the Hartz, in the forests of Thuringia, in Swabia, and elsewhere.   It is extracted from the juice of the sorrel called Alleluya. Juncker, Boerhaave, Margraff, and others, have described the process used for its extraction.   The juice of sorrel is expressed, diluted with water, filtered, and evaporated to the consistence of cream.   It is then covered with oil, to prevent its fermentation, and left in a cellar for six months.

According to M. Savary, fifty pounds of this plant afford five and twenty of juice, from which no more than two ounces and an half of the salt are obtained. Six parts of boiling water dissolve one of the salt.   It appears to crystallize in parallelopipedons, according to De Lisle.

Margraff observed that the nitric acid, digested upon salt of sorrel, afforded nitre.

Calcareous earth has the property of disengaging the alkali ; and in this operation the carbonic acid of the chalk unites with the alkali of the salt, and forms a carbonate of potash.

Salt of sorrel unites with other bases without yielding its own, so that the results are triple salts.   See the Encyclopedie Methodique, tom. i. p. 200, 201.

The pure oxalic acid may be obtained by distillation of this salt, as Mr. Savary informs us ; or otherwise by depriving it of its alkali by means of sulphuric acid, and distillation, according to Wiegleb's method : or otherwise by the process of Scheele, which consists in saturating the excess of acid with ammoniac, and pouring the nitrate of barytes into the solution.   The nitric acid then seizes the two alkalis, while the oxalic acid unites with the barytes, and falls down.   The barytes is afterwards taken from its combination by the sulphuric acid, and leaves the oxalic acid disengaged.

Scheele has likewise proposed another method of obtaining the pure oxalic acid.   It consists in dissolving the salt in water, and pouring in a solution of salt of saturn.   A precipitate is formed ; and the supernatant liquor contains the alkali of the salt of sorrel, united with a portion of the vinegar.   The precipitate is then washed, and sulphuric acid poured on, which unites with the

lead : and, by filtering and evaporating, the oxalic acid is obtained in crystals, similar to those of the acid of sugar.

Scheele has proved the identity of the acid of salt of sorrel with that which is extracted from sugar.   He dissolved the acid of sugar to saturation in cold water, and into this he very gradually poured a well-saturated solution of potash.   During the effervescence, he observed that small transparent crystals were formed, which were found to be a true salt of sorrel.

Mr. Hoffman has proved that the juice and the crystals of the berberis vulgaris contain the oxalic acid combined with potash.   And the celebrated Scheele has proved that the earth of rhubarb is a combination of the oxalic acid with lime.

ARTICLE IX.

Concerning the Vegetable Acids.

The vegetable acids have been long considered to be weaker than the others; and this opinion was adhered to until it was observed that the oxalic acid seized lime from the sulphuric acid.   The principal character which may serve to establish a line of distinction between the vegetable acids and others are—1. Their volatility; for there are none which do not rise with a moderate heat.   2. Their property of leaving a coaly residue after combustion, and of emitting an empyreumatic smell in burning.   3. The nature of their acidifiable base, which is in general oily.

But are all the vegetable acids identical in their nature? And may they not be considered as modifications of one and the same acids?

If we depend on the principle laid down by the celebrated Monro, who considers no acids as identical but such as form exactly the same salts with the same base (Phil. Trans. vol. lvii. p. 479), there will be no ques-

tion but that all the known acids ought to be considered as very different from each other. But this method of proceeding appears to me to be erroneous; because in this case the various degrees of saturation of the same principle with oxigene, would establish various kinds of acids. The slow or the rapid combustion of phosphorus causes sufficient modifications in the acid to afford different phosphoric salts, according to the Experiments of Messrs. Sage and Lavoisier. But ought we on this account to admit of two species of phosphoric acid? By following the method of Monro, which is that of most chemists, we might multiply the vegetable acids to infinity; but by collating the experiments of Hermstadt, Crell, Scheele, Westrumb, Berthollet Lavoisier, &c. we may observe that the vegetable acids are merely modifications of one or two primitive acids.

1. Scheele obtained vinegar by treating sugar and gum with manganese and the nitric acid. He observed that tartar had the same effect or habitude as sugar in the solution of manganese by the nitric acids; and that vinegar was found after the decomposition of ether.

2. Mr. Crell, by boiling the residue of nitric alcohol (dulcified spirit of nitre) with much nitric acid, taking care to adapt vessels to condense the vapour, and saturating what came over with alkali, obtained nitrate and the acetate of potash. The latter being separated by alcohol, gives out its vinegar by the usual treatment.

3. The same chemist, by boiling the pure oxalic acid with twelve or fourteen parts of nitric acid, observed that the former disappears; and the receiver is found to contain nitrous acid, acetous acid, carbonic acid, and nitrogenous gas; and in the retort there remains a little calcareous earth.*

4. By saturating the residue of nitric alcohol with chalk, an insoluble salt is obtained; which, treated with the sulphuric acid, affords a true tartareous acid.

* There being an obvious oversight in the author's paragraph, I have taken the liberty to restore the passage from Crell's original. Journal de Phys. Oct. 1785, quoted by Dr. Beddoes at the end of the English Translation of Scheele's Essays. London, 1789. T.

5. By boiling one part of oxalic acid with one part and a half of manganese, and a sufficient quantity of nitric acid, the manganese is almost totally dissolved, and vinegar with nitrous acid pass into the receiver.

6. By boiling tartareous acid and manganese with the sulphuric acid, the manganese is dissolved, and vinegar with sulphuric acid are obtained.

7. By digesting for several months the tartareous acid and alcohol, the whole becomes changed into vinegar; and the air of the vessels is found to consist of carbonic acid and nitrogene gas.

From these facts Crell concludes that the tartareous, oxalic, and acetous acids, are merely modifications of the same acid.

In the Journal de Physique for September 1787, is inserted a memoir of M. Hermstadt on the conversion of the oxalic and tartareous acids into acetous acid.

1. By causing the oxigenated muriatic acid to pass through very pure alcohol, ether is produced; and the oxigenated acid resumes its character of ordinary muriatic acid. The ether by distillation affords—1. Ether. 2. Muriatic alcohol. 3. Vinegar mixed with regenerated muriatic acid.

2. Nitric acid distilled, for several successive times, from the oxalic and tartareous acids, converts them totally into acetous acid.

3. Two parts of oxalic acid, three of sulphuric acid, and four of manganese, mixed with one part and a half of water, and distilled together, afford acetous acid, which requires to be recohobated and redistilled to become very pure.

4. If the sulphuric acid be boiled upon the oxalic or the tartareous acid, these two last are not destroyed, as Bergmann thought, but they are converted into acetous acid. It is proved, by the experiments of M. Hermstadt, that the sulphureous acid in the receiver, when ether is made, is mixed with much acetous acid.

It appears, therefore, to be proved that the tartareous, oxalic, and acetous acids differ from each other only in the proportion of oxigene.—In the above experiments the mineral acids are always decomposed; and, by saturating the radical with their oxigene, they constantly form the

acetous acid. If the saturation be not exact, the result is either oxalic or tartareous acid; which is still more proved by a fine experiment of M. Hermstadt. If three parts of fuming nitric acid be put into the pneumatic apparatus, and a large jar be adapted, filled with water; if then one part of good alcohol be poured in, by a little at a time, the mixture will be heated every time a drop of the alcohol is let fall, and a great quantity of bubbles will rise into the receiver. When the operation is ended, if care be taken to collect the gas, it will be found to consist of nitrous gas, a small quantity of carbonic acid, and about a twelfth part of the acetous air of Priestley. The residue affords oxalic acid and acetous acid. The oxalic acid disappears if the operation be continued; ether is formed; and the acetous acid remains, and becomes more in quantity.

Mr. Hermstadt has likewise succeeded in converting the acids of tamarinds, of citrons, of marc of grapes, the juice of plums, apples, pears, gooseberries, berberries, sorrel, and others, into the oxalic, tartareous, and acetous acids.

From all these experiments it appears, that the oxigene, combined with a principle of alcohol, forms the oxalic acid; and that a more accurate saturation of this principle with oxigene forms the tartareous and acetous acids.

M. Lavoisier has proved that the known vegetable acids do not differ from each other but in the proportion of hydrogene and carbone, and in their degree of oxigenation.

I have proved (in the Memoirs of the Academy of Sciences of Paris for the year 1786) that water impregnated with the gas disengaged from the juice of grapes in fermentation, passes to the state of acetous acid.

It appears that the vegetable acids may be considered in two very different points of view. Most of them exist in the plant itself; but the properties and acid characters are disguised by their combination with other principles, such as oils, earths, alkalis, &c. On the other hand, several acids are extracted from vegetables, which did not exist in nature. In this case the plant contained only the radical, and the reagent with which it is treated affords the oxigene.

.The mere distillation of most vegetables is sufficient to develop an acid, which was disguised by oily, alkaline, or earthy substances.

1. The peculiar acid called the Pyro-mucilaginous acid, is afforded by distillation by all plants which contain a saccharine juice.

For the preparation of this acid, the quantity of sugar intended to be operated upon is put into a very capacious retort (the large size being requisite, because the matter swells up), and a receiver sufficiently ample to condense the vapour is adapted. An astonishing quantity of carbonic acid and hydrogene gas are disengaged by the first impression of the fire. A brown fluid remains in the receiver, most of which consists of a weak acid, colouring blue paper, and rendered dark by a portion of oil. The retort contains a spongy coal. M. Schrickel advises the rectification of the product of the first distillation from clay, in order to purify the acid : but M. de Morveau has redistilled it without intermedium ; and the acid he obtained had only a slight yellow tinge. Its specific gravity was 1,0115, the thermometer standing at twenty degrees.

As this acid rises at the same temperature as water, it is not possible to concentrate it by distillation. But this purpose may be effected by freezing ; and in this manner it was that Mr. Schrickel prepared the acid he made use of to ascertain its combinations.

This acid exists in all bodies capable of passing to the spirituous fermentation, while they contain only the radical of the oxalic acid. The pyromucilaginous acid is combined in the vegetable with oils in the saponaceous state.

This concentrated acid has a very penetrating taste. It strongly reddens blue colours. If it be exposed to heat in open vessels, it is dissipated, and leaves only a brown spot. If it be heated in closed vessels, it leaves a more considerable residue, of the nature of the coal of sugar.

This acid speedily attacks the earthy and alkaline carbonates, and forms salts differing from the oxalates. According to Mr. Schrickel, it dissolves gold. He affirms that he made the experiment in the presence of Fred. Aug. Cartheuser. Lemery had asserted that the spirit of honey possessed this property ; and this opinion is likewise

supported in the works of Depré, Emuller, &c. Neuman opposed the assertion; and the experiments of M. de Morveau confirm those of this last chemist.

Silver is not attacked by the pyromucilaginous acid; but mercury combines with it by virtue of a long digestion. Consult de Morveau.

This acid corrodes lead, and forms a very styptic salt in long crystals. With copper it forms a green solution. It partly dissolves tin, and affords green crystals with iron.

2. The denomination of the Pyroligneous Acid has been given to the acid obtained by distillation from wood. It has been long known that the hardest woods afford an acid principle, mixed with an oil, which partly disguises its properties; but no one had directly attended to a determination of the habitudes of this acid, till M. Goettling published, in Crell's Annals for 1779, a series of researches on the acid of wood, and the ether it affords.

M. de Morveau, to obtain this acid, distilled small pieces of very dry beach in an iron retort, by a reverberatory furnace. He changes the receiver when the oil begins to rise, and rectifies his product by a second distillation. Fifty-five ounces of very dry chips afforded seventeen ounces of rectified acid, of an amber colour, not at all empyreumatic; whose specific gravity, compared with that of distilled water, was as 49 : 48.

This acid strongly reddens blue vegetable colours. One ounce required twenty-three ounces and a half of lime water for its complete saturation.

It supports the action of heat very well when it is engaged in an alkaline base; but by a strong heat it is burned, like all the vegetable acids.

It does not precipitate martial solutions of a black colour.

It unites with alkalis, earths, and metals. It does not give up lime or barytes to combine with caustic alkalis.

The action of the pyroligneous acid upon metallic substances, and upon alumine, may be compared with that of the acetous acid, and appears to follow the same order.

This acid dissolves near twice its weight of the oxide of lead.*

3. The citric acid.   Lemon juice is in a disengaged state in the fruit, and exhibits its acid properties without any preparation.   This acid is nevertheless always mixed with a mucilaginous principle, capable of altering by fermentation.   Mr. Georgius has described, in the Memoirs of Stockholm for the year 1774, a method of purifying this acid without changing its properties.   He fills a bottle with lemon juice, closes it with a cork, and preserves it in a cellar.   The acid was preserved for four years without corrupting.   The mucilaginous parts had fallen down in flocks; and a solid crust was formed beneath the cork, the acid itself having become as limpid as water.   To dephlegmate the acid, he exposes it to frost; and observes that the temperature ought not to be too cold, because in that case the whole would become solid; and though the acid would thaw the first, it would always be productive of some inconvenience.   In order to concentrate it to better advantage, the ice must be separated as it forms.   The first ice is tasteless, and the last is rather sour; and by this means the liquor is reduced to half.   The acid thus concentrated is eight times as strong, two gross only being required to saturate one gross of potash.

The citric acid, when thus purified and concentrated, may be kept for several years in a bottle; and serves for all uses, not excepting that of making lemonade.

The chemists in general who have examined the combinations of the citric acid, have used it in its original state embarrassed with its mucilaginous principle.   Such is the result of the experiments of M. Wenzel, who obtained only gummy products.   But M. de Morveau having saturated the purified acid with crystals of potash, found a non-deliquescent salt at the end of a certain time.

The combinations of this acid are little known.

* The pyromucous and pyroligneous acids are now considered to be the same as vinegar.—*Am Ed.*

4. The malic acid.—This acid was announced by Scheele in 1785, and published in Crell's Annals. In order to obtain it, the juice of apples is saturated with alkali, and the acetous solution of lead is poured in until it occasions no more precipitate. The precipitate is then edulcorated, and sulphuric acid poured on it until the liquor has acquired a fresh acid taste, without any mixture of sweetness. The whole is then filtered, to separate the sulphate of lead. This acid is very pure, always in the fluid state, and cannot be rendered concrete.

It unites with the three alkalis, and forms deliquescent neutral salts. When saturated with lime, it affords small irregular crystals, which are soluble only in boiling water. Its habitude with barytes is the same as with lime.

With alumine it forms a neutral salt of sparing solubility in water, and with magnesia a deliquescent salt.

It differs from the citric acid—1. Because the citric acid saturated with lime, and precipitated by the sulphuric acid, crystallizes; whereas this is not crystallizable. 2. The malic acid, treated with the nitric affords the oxalic acid; the citric does not afford it. 3. The citrate of lime is almost insoluble in boiling water; the malate of lime is more soluble. 4. The malic acid precipitates the solutions of the nitrates of lead, of mercury, and of silver; but the citric acid produces no change. 5. If the solutions of the nitrate of ammoniac, and malate of lime, be boiled together for an instant, the latter salt is decomposed, and nitrate of lime falls down; which proves that the affinity of the malic acid with lime is weaker than that of the nitric.

The celebrated Scheele, who has rendered us acquainted with this acid, has published the following table of the fruits which afford this acid, either pure or mixed with other acids.

The expressed juices of the fruits of

Berberris vulgaris, the Barberry Tree,
Sambucus nigra, Elder,
Prunus spinosa, Sloe,
Sorbus aucup. Service,
Prunus domestic, Garden Plum,
} Afford much malic acid, and little or none of the citric acid.

Ribes grossularia, the Hairy Gooseberry,
Ribes rubrum, the Currant,
Vaccinium mirtellus, Whortleberry,
Cratægus aria, Common Lotus,
Prunus Cerasus, Cherry,
Fragaria vesca, Strawberry,
Rubus chamemorus, Bilberry,
Rubus idæus, Raspberry,
} Appear to contain half of the one and half of the other.

Vaccinium oxycacos, Marshwhortle,
Vaccinium Vitis Idæa,
Prunus padus, Birds Cherry,
Solanum dulcamara,
Cynosbatos, Eglantine,
Citrus, Citron or Lemon,
} Contain much citric, and little or none of the malic acid.

According to the same chemist, the juice of green grapes, as well as that of tamarinds, contains only the acid of citrons.

Scheele has likewise proved the existence of the malic acid in sugar. If weak nitric acid be poured on sugar, and distilled till the mixture begins to turn brown, all the oxalic acid may be precipitated by the addition of lime-water; and another acid will remain, which the lime-water does not precipitate. To obtain this acid in a state of purity, the liquor is saturated by means of chalk, then filtered, and alcohol added, which, occasions a coagulation. This coagulation, well washed in alcohol, is redissolved in distilled water. The malate of lime is decomposed by the acetate of lead; and, last of all, the malic acid is disengaged by the sulphuric acid. The alcohol by evaporation leaves a substance rather bitter than sweet, which is deliquescent, and resembles the saponaceous matter of lemon juice. If a small quantity of nitric acid be distilled from this, the malic and oxalic acids are obtained.

By treating various other substances with the nitric acid, the malic and oxalic acids are likewise obtained. Such are gum arabic, manna, sugar of milk, gum adragant, starch, and the fecula of potatoes. The extract of nut-galls, the oil of parsley seed, the aqueous extract of aloes, of coloquintida, of rhubarb, of opium, afforded not only the two acids to Mr. Scheele, but likewise much resin.

This celebrated chemist, by treating several animal substances with very concentrated nitric acid, obtained the malic and the oxalic acids from them. Fish-glue, or isinglass, white of egg, yolk of egg, and blood, treated in the same manner, afforded the same products.

There are few vegetables which do not exhibit some acid more or less developed. We see, for example, all fruits insipid at first become insensibly acid ; and finish by losing that taste, and become saccharine. There are some which constantly preserve an acid taste, and form a a particular class.

Some plants contain an acid principle diffused through the whole parenchyma or body of the vegetable. Such are the yellow gilly-flower, bardana or waterdock, filipen-dula or dropwort, water cresses, the herb robert, &c. These plants sensibly redden blue paper.

There are others in which the acid principle exists only in part of the plant; as, for example, in the leaves of the greater valerian, the fruit of the winter cherry, and of the cornel tree, the bark of burdock, and the root of aristolochia or birthwort.

Mr. Monro communicated some experiments to the Royal Society of London, in 1767, which prove that certain vegetables contain acids nearly in a disengaged state, and even such as are the least promising on a slight examination.

1. Having peeled two dozen of summer apples, and cut them into small pieces, he poured water upon them, in which he had previously dissolved two ounces of soda, and left the whole to stand for six days. The filtrated liquor, evaporated, and left in repose for six days more, afforded a beautiful salt in small

round transparent plates, placed edgewise on each other.

2. The juice of mulberries clarified with the white of egg, and saturated with soda, afforded a pulverulent salt of no regular figure; which by repeated solutions and evaporations, at last produced long crystals, one kind being thin, and the other thicker, which crossed each other.

3. He obtained small cubical or rhomboidal crystals by treating peaches and oranges with soda.

4. The green plum afforded, after several solutions and crystallizations, a neutral salt, which crystallized without evaporation in large hexagonal plates, and partly in large rhombi. This salt had a hot taste, and was soluble in three or four times its weight of cold water.

5. The red gooseberry afforded, by evaporation and cooling, small very hard rhomboidal crystals, not changeable in the air; whose taste resembled that of the salt produced by a combination of the citric acid with the same base.

The green gooseberry produced a saline crust formed of small rhomboidal crystals, and covered with their brilliant scales.

6. The green grape afforded Mr. Munro, by repeated solutions, a neutral salt, in small cubical crystals, of a rhomboidal or parallelogramic figure, lying upon and intersecting each other.

The juice of hemloc afforded M. Baumé a salt in small irregular crystals, nearly tasteless, but reddening the infusion of turnsol.

6. M. Rinmann, in his History of Iron, places the sorb-apple and sloe among the substances capable of corroding and cleansing the surface of this metal, on account of their acid.

When, by the decomposition of certain vegetables by the nitric acid, an acid was obtained as the last result, it was thought to have existed ready formed in the vegetable; but a more intimate examination shewed that the acid made use of in this operation was merely decomposed, while it destroyed the organization of the vegetable, disunited the combinations which retained the prin-

ciples, and that the oxigenous base of this acid, by unit-
ing with an element of the vegetable, formed a particular
acid. This truth is deduced from the combined processes
of M. Lavoisier, De Morveau, &c.

It is to a similar cause that we ought to attribute the
formation of the acetous, the carbonic, and other vegeta-
ble acids; and even the rancidity of oils, and the altera-
tion to which some other principles of the vegetable king-
dom are subject. In these cases the air affords the oxi-
gene which becomes fixed in the plant, and gives it an
acid nature.

The oxalic acid does not exist ready formed in sugar,
neither is the camphoric acid ready formed in camphor.
The same may be observed of several other acids which
are extracted by means of certain acids decomposed by
being treated with vegetable substances. We shall speak
of these acids when we come to treat of their radical
principles.

ARTICLE X.

Concerning Alkalis.

Alkali exists ready formed in plants. Duhamel and
Grosse have proved that it might be extracted by means
of acids. Margraff and Rouelle have added new proofs
in support of the assertions of these chemists. They
have observed, from their experiments, that the alkali ex-
isted in a disengaged state in vegetables: but these expe-
riments proved at most that their state of combination is
such that it may be broken by the mineral acids. The
alkali, in some instances, is nearly in a disengaged state;
for it is found in combination with carbonic acid in the
helianthus annuus. But the alkali of plants is often com-
bined with the oily principle.

When it is required to extract the alkali from a vege-
table substance, all the principles with which it may be
united, are destroyed by fire; and it is cleared from the
residues of the combustion by lixiviation. This is the
process used to make the impure alkali, called *salin*, as
we have already observed.

If wood remains a long time under water, it is depriv-
ed of its property of affording an alkali by combustion;
because the water dissolves the compounds which may
contain it.

Marine plants afford an alkali of another nature, known
by the name of Soda. Vegetables possess the power of
decomposing common sea salt, and retaining its alkaline
base. All insipid plants are capable of affording more or
less of soda if they be raised on the sea coast; but they
perish there in a short time.

Ammoniac is likewise found in plants. The glutinous
part of gramineous vegetables contain it, and give it out
to the nitric, muriatic, and other acids, according to Mr.
Poulletier: and nothing more is required than to triturate
the essential salt of wormwood with fixed alkali, to sepa-
rate the volatile. This alkali appears to be one of the
principles of the tetradynamia, as these afford it by sim-
ple distillation.

Alkalis likewise exist in plants in the state of neutral
salts. They are combined with the sulphuric acid in old
borage and in some astringent plants. The sulphate of
potash appears to exist in almost all vegetables, as the pot-
ash contains more or less of it; and the analysis of to-
bacco has afforded me a considerable quantity.

Tamarisc affords the sulphate of soda in such abund-
ance, that by extracting it from the ashes of this plant, it
can be afforded in very beautiful and pure crystals at thirty
livres the quintal.

The greater turnsol, parietaria, and borage, contain
nitrate of potash.

The muriates of soda and of potash are afforded by
marine plants.

We likewise find the alkalis combined with the acids
of vegetation, such as the oxalic, the tartareous, and other
acids.

It appears that the several salts are the products of the
vegetation, and peculiar effect of the organization, of ve-
getables. Two plants which grow in the same soil, af-
ford very different salts; and each plant constantly affords
the same kind. Besides this, Homberg observed (Mem.
Acad. Par. 1669) that the same salts were developed by

plants growing in earths previously well washed, and afterwards watered with distilled water.

We may therefore class salts among the principles of vegetables, and no longer consider them as accidentally contained in plants. I do not however deny that the combustion of a plant may not give rise to some of them, and increase or diminish the proportions of others. Combustion must form combinations which did not exist in the plant, and destroy several of those which existed before. The atmospheric air employed in this operation must unite with certain principles, and produce various results. The nitrogene gas which is precipitated in torrents in the focus of combustion, probably combines with some of the principles to form alkalis, and consequently may augment the quantity of those which naturally exist in the plant.

ARTICLE XI.

Concerning the Colouring Principles.

The object of the art of dying consists in depriving one body of its colouring principle, to fix it upon another in a durable manner; and the series of manipulations necessary to produce this effect, constitutes the art itself. This art is one of the most useful and wonderful of any we are acquainted with; and if there be any one of the arts which is capable of inspiring a noble pride, it is this. It not only affords the means of imitating nature in the riches and brilliancy of her colours; but it appears to have surpassed her in giving a greater degree of brilliancy, fixity, and solidity to the fugacious and transient colours with which she has clothed the productions around us.

The series of operations which constitute the art of dying, are absolutely dependant on the principles of chemistry: and though it is to accidents, or the very slight combination of facts suggested by the comparison of a few circumstances, that we are indebted in this part of chemistry for several excellent receipts, and some principles; yet it is not the less true, that no considerable progress will ever be made, nor any solid foundation established, but by analysing the operations, and reducing them to ge-

neral principles, which chemistry alone can afford. The necessity of establishing proper principles is still farther evinced by the uncertainty and continual trials which prevail in the manufactories. The slightest change in the nature of the substances puts the artist to a stand, insomuch that he is incapable of himself of remedying the defects which arise. Whence follow continual losses, and a discouraging alternation of success and disappointment.

The little progress which chemistry has hitherto made in the art of dying, depends on several causes, which we shall proceed to explain.

The first cause of this slow progress depends on the difficulty of ascertaining with any degree of certainty the nature, properties, and affinities, of the colouring principle. In order to extract this principle, we must be acquainted with the nature of its solvent; we must know whether the principle be in a state of purity, or mixed with other parts of the vegetable; whether this colouring matter consist of one principle alone, or is formed by the union of a number: we must also render ourselves acquainted with its affinities with various kinds of stuff; for it is ascertained by experience that certain colours adhere very well to wool, though they do not alter the whiteness of cotton. In addition to these necessary parts of knowledge, it will likewise be required to determine its affinity with the mordant, for alum is the mordant for some colours and not others: besides which, the action or effect of other bodies upon the colour when dyed must be ascertained, in order to contrive the means of defending it from alteration, &c.

The second cause which has retarded the application of chemistry to dying, is the difficulty the chemist finds in procuring opportunities of making experiments in the large way. Prejudice, which reigns despotically in the dye-house, tends to expel the chemist as a dangerous innovator; and the proverb, that *Experience is better than Science*, contributes to prevent the introduction of improvements into manufactories. It is very certain that a dyer, confined to the mere practical part of his business, will without controversy produce a better scarlet than a chemist who is acquainted only with the principles; for the same reason as a simple workman in clock making

will make a better watch than the most celebrated mecha-
nic. In these cases we may admit that experience is bet-
ter than science; but when it is required to resolve any
problem, to explain any phenomenon, or to discover some
error in the complicated details of an operation, the
mere artizan is at the end of his knowledge, is to-
tally at a loss, and would derive the greatest advan-
tage from the assistance of the man of science.

Another cause of the slow progress of chemistry in the
art of dying, is, that most of the works which treat upon
this art are confined to descriptions of the processes used
in the manufactories. These works, it must be admit-
ted, possess their advantages; but they do not advance
the science of operations a single step. They only ex-
hibit the sketch of a country, without indicating either
its relative situation, or the nature of its products. It
has indeed been very difficult, till lately, to do more than
this; because the gases, which are so greatly concerned
in this part of chemistry, were unknown; because the
action of light and of the air, which is so powerful upon
colours, was a fact of which neither the cause nor the
theory could be known; and more particularly because
the salts and combinations of three, four and five princi-
ples were not known, though they very much tend to
render the effects of operations on vegetables more com-
plicated.

In order therefore to make a progress in the art of
dying, we must ground our reasoning on other princi-
ples. I shall proceed to sketch out a plan which seems
to me to be adapted to this purpose. We shall ex-
amine—

1. The manner in which the colours of various bodies
are developed and formed.

2. The nature of the combinations of these same
colours in these bodies, and the properest means of ex-
tracting them.

3. The most advantageous processes for applying
them.

1. Colours are all formed in the solar light. The proper-
ty which bodies possess of absorbing some rays, and re-
flecting others, forms the various tinges of colours with

which they are decorated, as is proved from the experi-
ments of Newton.

From this principle we may consider the art of dying
under two very different points of view. For we may
determine the colour upon a body either by changing the
form and disposition of its pores ; so that it may acquire
the property of reflecting a different kind of rays from
those which it reflected before it was subjected to these
mechanical operations. Thus it is that by trituration we
change the colour of many bodies; and to this cause it
is that we must refer all the effects dependant on the re-
flexibility and refrangibility of rays. This coloration
depends, as we see, merely on the changes produced in
the surfaces of bodies, or the disposition of their pores.
The phenomena of refrangibility depend on the density
or specific gravity of bodies, according to Newton and
Delaval.

The other method of causing a body to exhibit a de-
terminate colour, consists in transferring to the surface of
the body some other body or substance which pos-
sesses the property of reflecting this known ray. This
is the effect chiefly produced by dying.

But in what manner do the coloured bodies of the three
kingdoms of nature acquire the property of constantly
reflecting one determinate kind of rays ? This is a very
delicate question ; for the elucidation of which I shall
bring together a few facts.

It appears that the three colours which are the most
eminently primitive in the arts ; those which form all the
others by their combination, and consequently the only
colours to which we need pay attention ; that is to say,
the blue, the yellow, and the red—are developed in the
bodies of the three kingdoms by a greater or less absorp-
tion of oxigene, which combines with the various princi-
ples of those bodies.

In the mineral kingdom, the first impression of fire, or
the first degree of calcination, develops a blue colour,
sometimes interspersed with yellow, as is observable
when lead, tin, copper, iron, or other metals, are exposed
in a state of fusion to the action of the air, to hasten their
cooling. This may be especially observed in steel plates
which are coloured blue by heating.

Metals acquire the property of reflecting the yellow colour by combining with a greater quantity of oxigene; and accordingly we perceive this colour in most of them in proportion as the calcination advances. Massicot, litharge, ochre, orpiment, and yellow precipitate, are instances of this.

A stronger combination of oxigene appears to produce the red; whence we obtain minium, colcothar, red precipitate, &c.

This process is not uniform through all the bodies of the mineral kingdom; for it is natural to infer that the effects must be modified by the nature of the base with which the oxigene combines. Thus it is that in some of them we perceive the blue colour almost immediately followed by a black; as may easily be accounted for, on the consideration that there is a very slight difference between the property of reflecting the weakest rays and that of reflecting none at all.

To give additional force to the observations here made, we may also take notice that the metals themselves are most of them colourless, and become coloured by calcination; that is to say, by the fixation and combination of oxigene.

The effects of the combination of oxigene are equally evident in the mineral as in the vegetable kingdom; and, in order to convince ourselves of this, we need only follow the operations in the method of preparing and developing the principal blue colours, such as indigo, pastel, turnsol, &c.

Indigo is extracted from a plant known by the name of Anillo by the Spaniards, and the Indigo Plant by us. It is the *Idingofera tinctoria* of *Linnæus*. It is cultivated at Saint Domingo, in the Antilles, and in the East Indies. The boughs are cut every two months, and the root lasts two years. The plant is laid to ferment in a trough called the steeping trough, which is filled with water. At the end of a certain time the water heats, emits bubbles, and becomes of a blue colour. It is then passed into another vessel or trough, called the beating trough (batterie,) where the fluid is strongly beaten or agitated by a mill with pallets, to condense the substance of the indigo. As soon as the water is become insipid, it is drawn off;

and the deposition of the fecula is made in a third vessel, called the settling trough (reposoir), where it dries, and is taken out to form the loaves distributed in commerce.

The pastel is a colour which is extracted in Upper Languedoc, by fermenting the leaves of the plant after having first bruised them.   The fermentaion is promoted by moistening them with the most putrid water that can be procured.

The woad is prepared in Normandy in the same manner as the pastel.

Turnsol is prepared at Grand Galargues by soaking rags in the juice of the croton tinctorium, and afterwards exposing them to the vapour of urine or dung.

We likewise observe that the first degree of combination of oxigene with oil (in combustion) develops the blue colour for the instant.

The blue colour is formed in dead vegetables only by fermentation.   Now in these cases there is a fixation of oxigene.   This oxigene combines with the fecula in indigo, with an extractive principle in turnsol, &c.; and most colours are likewise susceptible of being converted into red by a greater quantity of oxigene.   Thus it is that turnsol reddens by exposure to air, or to the action of acids; because the acid is decomposed upon the mucilage, which is the receptacle of the colour; as may be seen in syrup of violets, upon which the acids are decomposed when concentrated.   The same thing does not happen when a fecula is saturated with oxigene, and does not admit of the decomposition of the acid.   Hence it is that indigo does not become red by acids, but is on the contrary soluble in them.   It is likewise for the same reason that we observe a red colour developed in vegetables in which an acid continually acts, as in the leaves of the oxalis, of the virgin vine, the common sorrel, and the ordinary vine.   Hence also it happens that acids brighten most of the red colours; and that a very highly charged metallic oxide is used as the mordant for scarlet.

We find the same colours developed in the animal kingdom by the combination of the same principle.

When flesh-meat putrefies, the first impression of the ox-
igene consists in producing a blue colour; whence the
blue appearance of mortifications, of flesh becoming pu-
trid, of game too long kept, or the appearance which in
our kitchens in France is called *cordon bleu*. This blue
colour is succeeded by red, as is observed in the prepara-
tion of cheeses, which become covered with a mouldiness
at first of a blue colour, but afterwards becoming red: I
have pursued these phenomena in the preparation of chee-
ses at Rocquefort. The combination of oxigene, and the
proportional quantity which enters into such combination,
determine therefore the property of reflecting any particu-
lar rays of light. But it may easily be understood that
the colour must be subject to variation, according to the
nature of the principle with which it combines; and this
points out a series of very interesting experiments that re-
main to be made.

All the phenomena of the combination of air with the
several principles in different proportions, may be observ-
ed in the flame of bodies actually on fire. This flame is
blue when the combustion is slow; red, when stronger
and more complete; and white, when still more perfect.
For these final degrees of oxidation in general produce a
white colour, because all the rays are then equally re-
flected.

From the foregoing facts we may conclude that the blue
ray is the weakest, and is consequently reflected by the
first combination of oxigene. We may add the following
fact to those we have already exhibited. The colour of
the atmosphere is blueish: the light of the stars is blue,
as M. Mariotte has proved, in the year 1678, by receiv-
ing the light of the moon upon white paper: the light of
a clear day reflected into the shade by snow, is of a fine
blue, according to the observations of Daniel Major (E-
phem. des. Curios. de la Nature, 1671, premier Dec.)

The colouring principle is found in vegetables in four
states of combination—1. With the extractive principle.
2. With the resinous principle. 3. With a fecula. 4.
With a gummy principle.—These four states in which
we find the colouring principle, indicate to us the means
of extracting it.

A. When the receptacle of the colour is of the nature of extracts, water is capable of dissolving the whole : such is that of logwood, turnsol, madder, cochenille, &c. Nothing more is necessary than to infuse these substances in water, for the purpose of extracting their colouring principle. If any stuff be plunged in this solution, it will be covered with a body of colour; which will be a mere stain, that may be again cleared off by water. To obviate this inconvenience, it has therefore been found necessary to impregnate the stuffs on which the colours were intended to be applied with some salt, or other principle, which might change the nature of the colouring matter, and give it fixity, by depriving it of its solubility in water. It is this substance which is distinguished by the name of Mordant. It is likewise necessary that the mordant should have an affinity with the principle of colour, in order that it may become its receiver. Hence it arises that most of these colours, such as turnsol, Brasil wood, &c. are not fixed by these mordants ; hence also it arises that cochenille does not form a fine scarlet, unless it has tin for its mordant. It is necessary, moreover, that the mordant have a due relation to the nature of the stuff; for the same composition which gives a fine scarlet colour to wool, gives a colour of wine lees to silk, and does not even change the white colour of cotton.

B. There are certain resinous colouring matters soluble in spirit of wine : such are the pharmaceutical tinctures : they are used only in the arts for dying ribbons. There are other colouring matters combined with feculæ, which water does not dissolve : rocou, archil, indigo, and the red colour of oriental saffron, are of this kind.

Rocou is a resinous fecula obtained by macerating the seeds of an American tree called Urucu in water. In this operation the extractive part is destroyed by fermentation, and the resinous fecula is collected in a paste of a deep yellow colour. The paste of rocou, diffused in water with the impure alkali called *cendres gravelées*, affords a fine orange colour.

Archil is a paste prepared by macerating certain mosses and lichens in urine with lime. Alkalis extract a violet colour. Archil is made in Corsica, in Auvergne, at Lyons, &c.

The Archil of the Canaries is less charged with lime. That which I procured, exhibited in its texture the fibres of the plant, not completely decomposed by the fermentation. The archil of the Canaries, or the archil in the herb, is afforded by a lichen called *Orcella, rocella, lichen fruticulosus, solidus, aphyllus, subramosus, tuberculis alternis, Linnæi.* The pareila or archil of Auvergne is made with the *lichen parellus* Linnæi.

The colouring matters of this class are all soluble in alkali or lime ; and these are the substances used to dissolve them in water, and precipitate them upon stuffs. Lime is the true solvent of indigo; but alkali is the solvent of other substances of the same class. For example : when it is required to make use of the colouring matter of bastard saffron, the first proceeding consists in washing it in much water, to clear it of the extractive and yellowish principle, which is very abundant; and the resinous principle is afterwards dissolved by means of alkali, from which solvent it is precipitated upon the stuffs by means of acids. In this manner it is that the poppy-coloured silk is made. This resinous principle may also be combined with talk, after it has been extracted by an alkali, and precipitated by an acid ; in which case the result is vegetable red. To make this pigment, the yellow colour of saffron or carthamus is first extracted by means of washing. Five or six per cent. of its weight of soda is mixed with the residue ; and cold water poured on, which takes up a yellow matter; and this, by the addition of lemon juice, deposites a red fecula. The red fecula, mixed with a levigated talk, and moistened with lemon juice, forms a paste, which is put into pots to dry. If the red be soluble in spirit of wine, it is vegetable ; but if not it is mineral, and is usually vermillion.

Acids may be used instead of alkalis in fixing some of these colours upon stuffs. To make a permanent blue, instead of dissolving indigo by means of lime, it is sometimes dissolved in oil of vitriol. This solution is poured into the bath, and the alumed stuff is passed through it. Flannels are dyed blue at Montpellier in this way. This operation depends merely on an extreme division of the indigo by the acid.

D. There are some colouring principles fixed by a re-
sin; but which, by the assistance of extractive matter,
may be suspended by water. The stuffs are boiled in this
solution; the resinous part applies itself to them, and ad-
heres with sufficient solidity not to be again carried off by
water.

No preparation is required to dye with these ingredients,
nothing more being necessary than to boil the stuff in a
decoction of the colour. The principal substances of this
kind are, the husk of walnuts, the roots of the walnut
tree, sumach, santal, the bark of elder, &c. All these
substances, which require no mordants, afford only a buff-
coloured tinge, which dyers call Root Colours. The co-
louring matter of certain vegetables may likewise be ex-
tracted by oils. In this way oils are coloured red by in-
fusing alkanet, or the root of a certain species of bugloss,
in them.

In order to apply colouring matter properly upon any
stuff, it is necessary to prepare the stuff, and dispose it to
receive the colouring principle. For this purpose it must
be washed, bleached, and cleared of that glutinous mat-
ter which defends it from the destructive action of the air
while it grows on the animal which affords it; and impreg-
nated with the mordant which fixes the colour, and gives
it peculiar properties.

A. The first operation required to dispose a stuff to
receive colour, is bleaching; because the whiter it is, the
more natural and accurate will be the colour it takes. If
this precaution be not taken, the success will be uncertain.
To bleach piece goods, the operator is satisfied with boil-
ing them in an alkaline lixivium, and exposing them af-
terwards to the air, to render the whiteness more perfect.
This operation depends on the action of the oxigene,
which combines with the colouring principle, and destroys
it; as is evidently demonstrated by the late experiments
of M. Berthollet on the oxigenated muriatic acid, which
bleaches cloths and cottons with such facility, that it is
already used for this purpose in several manufactories.

Cotton is bleached in some manufactories by a very in-
genious process. A boiler is firmly set in masonry, and
a cover fitted to it in the strongest manner; this boiler has
an elliptical figure. Alkali rendered caustic by lime is

put into the bottom of this vessel; and the goods intended to be bleached are put into a basket which prevents their touching the sides of the boiler. When the piece-goods are properly placed, the covering is fixed on, which is pierced by a very small aperture, to permit a portion of the aqueous vapour to escape. A degree of heat much superior to that of boiling water is excited in the solution of potash: and the heat, assisted by the corrosive action of the potash in this kind of Papin's digester, destroys the colouring principle of the cottons, and gives them the utmost whiteness.

B. That kind of gluten which envelops almost every animal substance, but more especially raw silk, is insoluble in water and in alcohol. It is only attacked by alkalis and soaps; and for this purpose the operation of cleansing is used. Any stuff may-be cleared of its glutinous part by boiling or even digesting it in a solution of alkali: but it has been observed that a pure alkali alters the goodness and quality of the stuff; for which reasons soaps have been substituted in its stead. For this purpose the stuff is steeped in a solution of soap, heated to a less degree than boiling. The academy of Lyons, in the year 1761, proposed a prize for the means of clearing raw silks without soap. It was adjudged to M. Rigaut, of St. Quentin, who proposed a solution of salt of soda.

It has been lately ascertained that water, heated above the degree of ebullition, is capable of dissolving this colouring principle. A boiler similar to that which I have just described, may be used for this purpose.

In order to bleach cotton, and dispose it for the dying processes, it is cleansed by means of a liquid soap made of oil and soda.

The piece-goods are cleared by this boiling from the varnish, which would prevent the colour from applying and fixing itself in a permanent manner; at the same time that it opens the pores of the stuff for the better reception of the colour.

When the piece is thus prepared, its pores being very open, and its colour very white, nothing remains to be done previous to the application of the dye, but to impregnate it with the mordant or principle which is to receive the colour and change its nature so much, that nei-

ther water, soap, nor any of the reagents used as proofs, may be capable of extracting it. It is necessary therefore —1. That the mordant itself should be very white, that it may not alter the colour presented to it. 2. That it be not subject to corruption; and for this purpose it must be sought among the earths and metallic oxides. 3. That it be in a state of extreme division, in order that it may fix itself in the pores. 4. That it be insoluble in water and the other reagents. 5. That its affinity with the colouring matter and the stuff be very great.

Alum and the muriate of tin, are the two salts whose bases unite these properties in the most efficacious manner. The stuffs having undergone the previous operations are therefore steeped in solutions of these salts; and when they are impregnated, they are passed through the colouring bath : and by the decomposition, or change of principles between the mordant and the principle which holds the colour in solution, the colour is precipitated on the base of the mordant, and adheres to it.

Certain vegetable substances are likewise disposed to take some colours by animalizing them. In this way cow's dung and bullock's blood are used in dying cotton; for it is a decided fact that animal substances take colours better than vegetables.

ARTICLE XII.

Concerning the Pollen, or Fecundating Power of the Stamina of Vegetables.

Modern discoveries and observations have pointed out the sexual parts of plants; and we find nearly the same forms in the organs, the same means in the functions, and the same characters in the prolific humours, as in animals.

The prolific humour in the male part is elaborated by the anthera; and as the organs of the plant do not admit of an actual intromission of the male into the female, because vegetables are not capable of loco-motion, nature has bestowed on the fecundating seed the character of a powder; which the agitation of the air, and other causes, may carry away and precipitate upon the female. There

is a degree of elasticity in the anthera, which causes it to open, and eject the globules. It has even been observed that the pistil opened at the same time, to receive the pol- len, in certain vegetables. The resources of nature to assure the fecundation are admirable. The male and fe- male parts almost always repose in the same flower; and the petals are always disposed in the most advantageous manner to favour the reproduction of the species. Some- times the male and female are upon the same individual, but placed upon different flowers; at other times both are attached to isolated and separate individuals, and then the fecundation is made by the pollen which the wind or air detaches from the antheræ, and transmits to the female.

The fecundating powder has almost constantly the smell of the spermatic liquor of animals. The smell of cab- bages in blossom, of the chesnut tree, and most other ve- getables, exhibits this analogy to such a degree, that the one odour might even be mistaken for the other.

The pollen is generally of a resinous nature, soluble in alkalis and in alcohol. Like resins, it is inflammable; and the *aura* which is formed around certain vegetables at the time of fecundation, may be set on fire, as was ob- served by Mademoiselle Linné in the fraxinella.

Nature, which has employed less œconomical means in the fecundation of plants, and who entrusts these opera- tions almost to chance, since she delivers the fecundating powder to the winds, must of course have been prodigal in the formation of this humour, more especially for the trees of the monoecia and dioecia genera, where the pro- duction is more exposed to accidental impediments. Hence we may account for those pretended showers of sulphur, which are never common but in such districts as abound with the hazel, filbert, and pine-trees.

As the pollen could not be exposed by nature to the va- rying temperatures of the atmosphere, she has facilitated its development in the most rapid manner. A warm sun very frequently suffices to open the concealed organs of the plant, to develop and procure its fecundation. On this account the author of *Les Etudes de la Nature* affirms, that the coloration of plants is designed to reflect the light more vividly, and that most flowers affect the most advan-

tageous form to concentrate the solar rays on the parts of
generation.

The parts employed in these functions are endued with
an astonishing degree of irritability.   M. des Fontaines
has made some very interesting observations on this sub-
ject ; and the agitated motions which some plants affect in
order to follow the course of the sun, are determined by
nature, in order that the great work of generation, favour-
ed by the sun, may be accomplished in the least possible
time.

Concerning Wax.

The wax of bees is merely the pollen very little altered.
These insects have their *femurs* provided with rugosities
to brush the pollen from the antheræ, and convey it to
their nests.

There appears to exist in the very texture of some
flowers, which are rich in fecundating powder, a matter
analogous to wax, which may be extracted by aqueous
decoction.   Such are the male catkins of the betula alnus,
those of the pine, &c. the leaves of rosemary, of offici-
nal sage, the fruits of the miriea cerifera, suffer wax to
transude through the pores.

It appears that wax and the pollen have for their basis
a fat oil, which passes to the state of resin by its combi-
nation with oxigene.   If the nitric or muriatic acid be di-
gested upon fixed oil for several months, it passes to a
state resembling wax.

Wax by repeated distillations, affords an oil which pos-
sesses all the properties of volatile oils.   It is reduced into
water and carbonic acid by combustion.

The colouring matter of wax appears to be of the same
nature as that of silk ; it is insoluble in water and in alco-
hol. . In the arts, wax is bleached by dividing it prodigi-
ously ; for which purpose oil is poured in fusion upon the
surface of a cylinder, which revolves at the surface of
water.   The wax which falls applies itself to the super-
ficies, and is reduced into very thin flakes or ribbons.   It
is afterwards exposed to the air upon tables, taking care

to stir it from time to time, and by this means it becomes white.

Alkalis dissolve wax, and render it soluble in water. It is this saponaceous solution which forms the Punic wax.   It may be used as the basis of several colours; and may be made into an excellent paste for washing the hands.   It is likewise applied with a brush upon several bodies: but it would be highly advantageous if it could be deprived of its solvent, which constantly acts, and is the cause why it cannot be applied to several uses, in which otherwise it might be found advantageous.

Ammoniac likewise dissolves it; and as this solvent is evaporable, it ought to be preferred when it is proposed to use the wax as a varnish.

ARTICLE XIII.

Concerning Honey.

Honey, or the nectar of flowers, is contained chiefly in the base of the pistil, or female organ.   It serves as food for most insects which have a proboscis.   These animals plunge their proboscis into the pistil, and suck out the nectar.   It appears to be a solution of sugar in mucilage; the sugar is sometimes precipitated in crystals, as in the nectar of the flower of balsamina.

The nectar undergoes no alteration in the body of the bee, since we can form honey by concentrating the nectar.   It retains the odour, and not unfrequently the noxious qualities of the plant which affords it.

The secretion of the nectar is made during the season of fecundation.   It may be considered as the vehicle and recipient of the fecundating dust, which facilitates the bursting of the globules, filled with this fecundating powder: for Linnæus and Tournefort have

both observed that nothing more is required than to expose the pollen upon water, to assist the development. All the internal part of the style of the pistil is impregnated with it. And if the internal part of the female organs be dried by heat, the pollen no longer fecundates.

Honey exudes from all the female parts, but particularly from the ovaria. Pores may even be observed in hyacinths, through which it flows.

Such flowers as have only the male parts do not in general afford honey; and the organs which afford the nectar dry up and wither from the moment the act of conception is accomplished. Honey may therefore be considered as necessary to fecundation; it is the humour afforded by the female to receive the fecundating powder, and facilitate the opening and explosion of the small bodies which contain the pollen; for it has been observed that these bodies open the moment they touch the surface of any liquid which moistens them.

ARTICLE XIV.

Concerning the Ligneous Part of Vegetables.

Chemists have constantly directed their attention to the analysis of vegetable juices: but they appear to have completely neglected the solid part of the vegetable, which in every point of view is entitled to particular attention. It is this ligneous portion which forms the vegetable fibre; and this matter not only constitutes the basis of the vegetable, but is likewise developed in circumstances which depend on the vital functions of the plant. It forms the pulp of seeds, the lanuginous covering which overspreads certain plants, &c. The character of the ligneous part is, an insolubility in water and almost every other menstruum. The sulphuric acid only blackens it, and is decomposed upon it, as is likewise the nitric acid. But one very peculiar character of this principle is, that the concourse of air and water alters it very difficultly; and

that when it is well deprived of all its moisture, it abso-
lutely resists every kind of fermentation; insomuch that
it would be indestructible, if insects had not the proper-
ty of gnawing and feeding upon it. It appears that the
vegetable fibre consists of the basis of mucilage, harden-
ed by its combination with a greater quantity of oxigene.
Several reasons lead us to adopt this idea. In the first
place, the diluted nitric acid being put to digest upon
fecula is decomposed, and causes the fecula to pass to
a state resembling that of ligneous matter. I have ob-
served, in the second place, that those fungi which grow
in subterraneous places void of light, and are resolved
into a very acid water, if left in a vessel, acquire a
greater quantity of the ligneous principle, in proportion
as they are exposed by degrees to the light; at the same
time that the acid is diminished by decomposition, and at
length disappears.

The transition of mucilage to the state of ligneous
matter is very evident in the growth of vegetables.
The cellular envelop which is immediately covered by
the epidermis exhibits nothing but mucilage and glands;
but by degrees it hardens, forms a stratum of the corti-
cal coating, and at last concludes by becoming one of
the ligneous rings.

We observe this transition in certain plants which are
annual in cold climates, and vivacious in temperate
climates. In the former they are herbaceous, because
the periodical return of the cold weather does not permit
them to develop themselves. In the second they become
arborescent; and the progress of time hardens the muci-
lage, and forms ligneous coatings.

The induration of the fibrous part may be accelerated
by causing the air and light to act more strongly upon it.
M. de Buffon has observed that, when a tree is deprived
of its bark, the external part of the wood which is ex-
posed to the air acquires a considerable degree of hardness;
and trees thus prepared form pieces of carpentry much
more solid than those which have not undergone such
preparation.

It is probably owing to the large quantity of pure air
with which the fibrous matter is loaded, that it is not dis-

posed to putrefy: and it is in consequence of this most va-
luable property of not being subject to corruption, that arts
have been invented for clearing it of all fermentable prin-
ciples of the vegetable kingdom, to obtain it in its greatest
purity in the fabrication of cloths, paper, &c.   We shall
again return to these objects, when we treat of the altera-
tions to which the vegetable kingdom is subject.

ARTICLE XV.

Concerning other fixed Principles of the Vegetable Kingdom.

The volatile oil of horse-radish had formerly afforded
sulphur, which is deposited by standing, according to
the observations of some chemists; but M. Deyeux
has taught us to extract this inflammable principle
from the root of the herb patience.   Nothing is re-
quired to be done but to rasp the root, boil, take off the
scum, and dry it.   This scum affords much sulphur in
substance ; and it is perhaps to this principle that these
plants owe their virtue, since they are used in skin dis-
orders.

Vegetables in their analysis likewise present us with
certain metals, such as iron, gold, and manganese.   The
iron forms near one-twelfth of the weight of the ashes of
hard wood, such as oak.   It may be extracted by the
magnet.   It does not appear to exist in a perfectly dis-
engaged state in the vegetable ; nevertheless we read, in
the Journaux de Physique, an observation in which it is
affirmed, that it was found in metallic grains in fruits.
The iron is usually held in solution in the acids of vege-
tation, from which it may be precipitated by alkalis.
The existence of this metal has been attributed to the
wearing of ploughshares, and other instruments of hus-
bandry, and to the faculty which plants possess of imbib-
ing it with their nutritive juices.   The Abbé Nolet and
others have embraced this unphilosophical notion.   It is

the same with the iron as with the other salts.   They are produced by vegetation; and vegetables watered with distilled water afford it as well as others.

Beccher and Kunckel ascertained the presence of gold in plants.   M. Sage was invited to repeat the processes by way of ascertaining the fact.   He found gold in the ashes of vine twigs, and announced it to the public. After this chemist, most persons who have attended to this object have found gold; but in much less quantity than M. Sage had announced.   The most accurate analyses have shewn no more than two grains; whereas M. Sage had spoken of several ounces in the quintal. The process for extracting gold from the ashes consists in fusing them with black flux and minium.   The lead which is produced is then cupelled, to ascertain the small quantity of gold with which it became alloyed in this operation.

Scheele has also obtained manganese in the analysis of vegetable ashes.   His process consists in fusing part of the ashes with three parts of fixed alkali, and one-eighth of nitrate of potash.   The fused matter is boiled in a certain quantity of water.   The solution being then filtered, is saturated with sulphuric acid, and at the end of a certain time manganese falls down.

Lime constantly enough forms seven-tenths of the fixed residue of vegetable incineration.   This earth is usually combined with the carbonic acid.   Scheele has proved that it effloresces in this form on the bark of guaiacum, the ash, &c.   It is likewise very often united with the acid of vegetation.   It appears to be formed by an alteration of the mucilage, more advanced than that which forms the fecula, which has some analogy with this earth. We evidently see the transition of mucilage to the state of earth in testaceous animals.   We observe the mucilage putrefy at its surface, with so much the more facility as it is purer; as we may judge by a comparison of the asteriæ, the sea hedge-hog, the crab, &c.

Next to lime, alumine is the most abundant earth in vegetables, and next magnesia.   M. Darcet has obtained, from one pound of the ashes of beech, one ounce of the sulphate of magnesia, by treating them with the

sulphuric acid. This earth is very abundant in the ashes of tamarisc. Siliceous earth likewise exists, but less abundantly. The least common of all is the barytes.

ARTICLE XVI.

Of the common Juices extracted by Incision or Expression.

The vegetable juices hitherto treated of are peculiar substances contained in vegetables, and possessing striking characters, by which they are distinguishable from every other humour. But we may at once extract from vegetables all the juices they contain; and this mixture of various principles may be obtained by several methods. Simple incision is sometimes sufficient; but expression is equally used.

The juices of vegetables vary according to the respective nature of the plants. They are more abundant in some than in others. Age modifies them. Young trees in general have most sap; and this sap is milder, more mucilaginous, and less charged with oil and resin. The sap varies according to the season. In the spring the plants draw up with avidity the juices afforded by the air and the earth; these juices establish a plethora every where, from which results a considerable growth of the individual, and sometimes a natural extravasation. If in the time of plethora incisions be made in any part of the vegetable, all the abundant sap escapes by the aperture; and this fluid is almost always clear, and without smell. But by degrees the plant elaborates these juices, and gives them peculiar characters. In the spring the sap in the body of the vegetable presents only a slight alteration of the nutritive juices; but in the summer the whole is elaborated, all is digested, and then the sap possesses characters very different from those it possessed during the spring season. If incisions be now made in the tree, the juices obtained are accordingly very different; and for this reason it is that the juices dispersed in commerce are extracted during the summer.

The constitution of the air equally influences the nature of vegetable juices. A rainy season opposes the development of the saccharine principle, as well as the formation of resins and aromatic substances. A dry season affords little mucilage, but much resin and aromatic principle; hot weather decomposes the mucilage, and favours the development of resins, saccharine matter, and aroma; but a cold season does not permit the formation of any principle but mucilage : and as the mucilage is the principle of increase of bulk in plants, the whole of this substance is employed for that purpose; while the heat and light modify the same mucilage, and cause it to pass to the state of oil, resin, aroma, &c. Hence probably it is that trees have a more agreeable appearance in cold than in burning climates; and that the trees in this latter situation abound with aromatic, oily, and resinous principles. In the vegetable as in the animal kingdom, spirit appears to be the portion of the southern climates; while force and strength are attributes of the northern.

Concerning the Juices extracted by Incision.

The juice contained in plants, and known by the name of Sap, is dispersed through the cellular tissue, enclosed in the vessels, or deposited in the utricules : and there is a communication existing, which, when any part of the vegetable is wounded, causes the abundant juices to flow through the aperture; not indeed so speedily, nor so completely, as in animals; because the humours do not possess so rapid a motion, and because there is less connextion between the several organs in vegetables than in animals. The sap is a confused mixture of all the principles of vegetables. The oil and the mucilage are confounded with the salts. It is, in a word, the general humour of vegetables, in the same manner as the blood in animals. In the present place we shall speak only of manna and opium.

1. Manna.—Several vegetables afford manna; and it is extracted from the pine, the fir, the maple, the oak, the juniper, the fig, the willow, the olive, &c. but the ash,

larch, and the alhagi, afford it in the largest quantities. L'obel, Rondelet, and others, have observed at Montpellier, upon the olive trees, a kind of manna, to which they have given the name of œliomeli. Tournefort collected it from the same trees at Aix, and at Toulon.

The ash which affords manna grows naturally in all temperate climates; but Calabria and Sicily appear to be the most natural countries to this tree; or at least it is only in these countries that it abundantly furnishes the juice called Manna in commerce.

The manna flows naturally from this tree, and attaches itself to its sides in the form of white transparent drops; but the extraction of this juice is facilitated by incisions made in the tree during summer: the manna flows through these apertures upon the trunk of the tree, from which it is detached with wooden instruments. Care is likewise taken to insert straws, or small sticks of wood, into these incisions; and the stalactites which hang from these small bodies are separated, and known in commerce by the name of Manna in Tears: the smallest pieces form the manna in sorts or flakes; and the common or fat manna is of the worst quality, because the most contaminated with earth and other foreign substances. The ash sometimes affords manna in our climates, specimens of which I have seen collected in the vicinity of Aniane.

The larch which grows abundantly in Dauphiny, and the environs of Briançon, likewise affords manna. It is formed during the summer on the fibres of the leaves, in white friable grains, which the peasants collect and put into pots, which they keep in a cool place. This manna is of a yellow colour, and has a very nauseous smell.

The alhagi is a kind of broom, which grows in Persia. A juice transudes from its leaves, in the form of drops of various sizes, which the heat of the sun indurates. An interesting account of this tree may be seen in Tournefort's Travels. This manna is known in the Levant, in the town of Tauris, by the name of Tereniabin.

The manna most frequently used is that of Calabria. Its smell is strong, and its taste sweetish and nauseous: if exposed on hot coals, it swells up, takes fire, and leaves a light bulky coal.

Water totally dissolves it, whether hot or cold. If it be boiled with lime, clarified with white of egg, and concenrated by evaporation, it affords crystals of sugar.

Manna affords by distillation water, acid, oil, and ammoniac ; and its coal affords alkali.

This substance forms the basis of most purgative medicines.

2. Opium.—The plant which affords opium is the poppy, which is cultivated in Persia and Asia Minor. To extract this precious medicine, care is taken to cut off all the flowers which would load the plant, and to leave that only which corresponds with the principal stem. At the beginning of summer, when the poppy-heads are ripe, incisions are made quite round them, from which tears flow that are carefully collected. This opium is the purest, and is retained in the country for various uses. That which comes to us is extracted by pressure from the same heads. The juice thus obtained is wrapped up, after previous drying, in the leaves of the poppy, and comes to us in the form of circular flattened cakes.

In our laboratories it is cleared from its impurities by solution in hot water, filtration, and evaporation to the consistence of an extract. This is the extract of opium.

Opium contains a strong and narcotic aroma, from which it is impossible to clear it, according to Mr. Lorry. It likewise contains an extract soluble in water, and a resin; together with a volatile concrete oil, and a peculiar salt.

By long digestion in hot water the volatile oil becomes attenuated, is disengaged, and carries the aroma with it; so that by this means the oil and aroma may be separated, at least for the most part. It has been observed that opium deprived of this oil, a portion of its aroma, and its resin, preserved its sedative virtue, without being narcotic and stupifying. We are indebted to Baumé for a series of interesting researches on this subject. He boiled four pounds of sliced opium in between twelve and fifteen pints of water, for half an hour. The decoction was strained with pressure, the dregs were exhausted by ebullition with more water. All these waters were mixed together, and reduced by evaporation to six pints. The liquor was then put into a cucurbit of tin, and digested on

VOL. II.   Q q

a sand-bath for six months, or during three months night and day. Care was taken to add water as the evaporation proceeded; and the bottom of the vessel was scraped from time to time, to disengage the resinous matter which subsided. When the digestion was finished, the liquor was filtered, the residue carefully separated, and the water evaporated to the consistence of an extract.

If the salt be required to be separated, the evaporation must be suspended when the fluid is reduced to one pint. An earthy salt falls down by cooling, which is of a ruddy appearance, and has the form of scales mixed with needled crystals.

By this long but judicious process, the oil is first separated; which after three or four days rises to the surface of the liquor, where it forms an adhesive pellicle, like turpentine. This pellicle is gradually dissipated, and disappears at the end of a month, nothing more being seen than a few drops from time to time. In proportion as the oil is dissipated, the resin, which formed a soap with it, is precipitated.

Mr. Baumé has calculated that these principles exist in the following proportions:—Four pounds of common opium afford one pound one ounce of marc or insoluble matter, one pound fifteen ounces of extract, twelve ounces of resin, one gross or dram of salt, three ounces seven gros of dense oil or aroma.

Mr. Bucquet proposed to extract the sedative principle, by dissolving it in the cold, and afterwards evaporating it; Mr. Josse, by agitating it in cold water; Messrs. De Lassone and Cornette, by dissolving, filtering it several times, and always evaporating it to the consistence of an extract.

The sedative principle is a medicine of the greatest value, because it does not produce that drunkenness and stupor which are too commonly the effects of crude opium.

When a plant does not afford its juice by incision, this may happen either because the quantity is too small, or because its consistence is not sufficiently fluid, or because there is not a sufficiently perfect communication between the vessels of the plant to permit the flowing of all the juice. In these cases the desired effect may be produced either by simple mechanical pressure,

as in extracting the juice of hypocistus and acacia; or by the assistance of water, which softens the texture of the vegetable, at the same time that it dissolves and carries off the juice.

Concerning Vegetable Juices extracted by Pressure.

The succulent vegetables afford their juice by simple pressure; and the method of performing this operation is nearly the same in all plants. When it is intended to extract the juice of a plant, it is washed, cut into small pieces, pounded in a marble mortar, put into a linen bag, and pressed in a press.

There are some ligneous plants, such as sage, thyme, and the lesser centaury, whose juices cannot be extracted without the additon of a small quantity of water; there are other very succulent plants, such as borage, bugloss, and chicory, whose juices are so viscid and mucilaginous as not to pass through a cloth unless a small quantity of water be added during the pounding. Inodorous plants may likewise be left to macerate, in order to prepare them for the extraction of their juices. The vegetable juices may be clarified by simple repose, or by filtration; when very fluid, by white of egg, or animal lymph, boiled with them; and when the juices contain principles which may be evaporated, such as those of sage, balm, majoram, &c. the vial which contains the juice is plunged in boiling water, after having closed it with a paper with a hole pierced through it; and when the juice is clarified, it is taken out, dipped in cold water, and decanted.

The juice of acacia is extracted from the same tree which affords gum arabic. The fruits of this tree are collected before they are ripe; then pounded, pressed, and the juice dried in the sun : it forms balls of a blackish brown internally, redder externally, and of an astringent taste.

A juice is prepared with unripe sloes, which is sold under the name of German Acacia, and does not differ much from that of Egypt.

The juice of hypocistus is extracted from a parasitical plant which grows on the cistus in the island of Crete. The fruit is pounded, the juice extracted by pressure, and thickened in the sun; it becomes black, and of a firm consistence.

These two last mentioned juices are used in medicine as astringents.

SECTION IV.

Concerning such Principles as escape from Vegetables by Transpiration.

VEGETABLES being endued with digestive organs, throw off all such principles as cannot be assimilated by them; and when the functions of the vegetable are not favoured by such causes as facilitate them, the nutritive juices are rejected nearly unaltered. We shall here attend to three principal substances that exhale from vegetables, viz. air, water, and aroma.

ARTICLE I.

Concerning Oxigenous Gas afforded by Vegetables.

Dr. Ingenhousz published, in the year 1779, Experiments upon Vegetables, in which he affirms that plants possess the property of emitting vital air when acted upon by the direct rays of the sun; and that they emit a very mephitic air in the shade, and during the night.

Doctor Priestley made known the same results at the same time, as well as Mr. Senebier of Geneva, who nevertheless did not publish a work on this subject until the year 1782, in which he admits, as a general principle, that plants suffer vital air to escape in the sun-shine : but he maintains that they do not produce mephitic air in the shade ; and is of opinion that, if Dr. Ingenhousz obtained any, it arose from a commencement of putrefaction in the plant.

The simplest process for extracting this gas from vegetables, consists in immersing them under water, beneath an inverted glass vessel. It is then seen, when the sun acts on the plant, that small bubbles are emitted, which gradually grow larger, arise from the fibres of the leaf, and ascend to the surface of the fluid.

All plants do not afford gas with the same facility. There are some which emit it the moment the sun acts upon them : such are the leaves of the jacobæa, of lavender, and of some aromatic plants. In other plants the emission is slower ; but in none later than seven or eight minutes, provided the sun's light be strong. The air is almost totally furnished by the inferior surface of the leaves of trees : it is not the same with herbs ; for these afford air from nearly the whole of their surface, according to Senebier.

The leaves afford more air when attached to the plant than when gathered ; and the quantity is likewise greater the fresher and sounder they are.

Young leaves afford but a small quantity of vital air ; those which are full grown afford more, and the more the greener they are. Leaves which are injured, yellow, or red, do not afford it.

Fresh leaves cut in pieces afford air ; and the oxigene gas is capable of being emitted without the plant being plunged under water, as is proved from the experiments of Mr. Senebier.

The parenchyma of the leaf appears to be the part which emits the air. The epidermis, the bark, and the white petals, do not afford air ; and in general it is only the green parts of plants which afford oxigenous gas.

Green fruits afford air, but those which are ripe do not; and the same is true of grain.

It is proved that the sun does not act in the production of this phenomenon as a body which heats.   The emission of this gas is determined by the light; and I have even observed that a strong light, without the direct action of the sun's rays, is sufficient to produce this phenomenon.

It is proved, by the experiments of Mr. Senebier, that an acid diluted in water increases the quantity of air which is disengaged, when the water is not too much acidulated; and in this case the acid is decomposed.

It has been observed that the conferva affords much vital air; as well as the green matter which is formed in water, and is supposed by Ingenhousz to be a collection of greenish insects.

Pure air is therefore separated from the plant by the action of light; and the excretion is stronger accordingly as the light is more vivid.   It seems that light favours the work of digestion in the plant; and that the vital air, which is one of the principles of almost all the nutritive juices, more especially of water, is emitted, when it finds no substance to combine with in the vegetable.   Hence it arises that plants whose vegetation is the most vigorous, afford the greatest quantity of air: and hence likewise it is that a small quantity of the acid mixed with the water favours the emission and increases the quantity of oxigenous gas.

By this continual emission of vital air, the Author of nature incessantly repairs the loss which is produced by respiration, combustion, and the alteration of bodies, which comprehends every kind of fermentation and putrefaction; and in this manner the equilibrium between the constituent principles of the atmosphere is always kept up.*

* *Vide* Note, page 80, vol: 1.

ARTICLE II.

Concerning the Water afforded by Vegetables.

Plants likewise emit a considerable quantity of water, in the form of vapour, through their pores ; and this ex- cretion may be estimated as the most abundant. Hales has calculated that the transpiration of an adult plant, such as the helianthus annuus, was in summer seven times more considerable than that of man.

Guettard has observed that this excretion is always in proportion to the intensity of the light, and not of the heat; so that there is scarcely any during the night. The same philosopher has observed that the aqueous transpiration is more especially made from the upper surface of the leaf. The water which exhales from vegetables is not pure, but serves as the vehicle of the aroma ; and even carries with it a small quantity of extractive matter, which causes it to corrupt so speedily.

The immediate effect of the aqueous evaporation con- sists in maintaining a degree of coolness in the plant, which prevents its assuming the temperature of the atmos- phere.

ARTICLE III.

Concerning the Aroma, or Spiritus Rector.

Each plant has its characteristic smell. This odorant principle was distinguished by Boerhaave by the name of Spiritus Rector, and by the moderns under the name of Aroma.

The aroma appears to be of the nature of gas, from its fineness, its invisibility, &c. The slightest heat is suffi- cient to expel it from plants. Coolness condenses it, and renders it more sensible ; and on this account the smell of plants is much stronger in the morning and evening.

This principle is so subtile, that the continual emission of it from a wood or flower does not diminish its weight, even after a very considerable time.

The aroma is sometimes fixed in an extract, sometimes in an oil, and this last combination is the most usual. It even appears to constitute the volatile character of the essential or volatile oils.

The nature of the aroma appears to vary prodigiously; at least if we may judge by the organ of smell, which distinguishes several species. There are some which have a nauseous or poisonous effect on the animal economy. Ingenhousz quotes an instance of the death of a young woman occasioned by the smell of lilies, in 1719; and the famous Triller reports the example of a young woman who died in consequence of the smell of violets, while another was saved by removing the flowers. Martinus Cromerus exhibits likewise an example of a bishop of Breslau who died by a similar cause.

The mancenille tree which grows in the West-Indies, emits very dangerous vapours. The humour which flows from this tree is so unwholesome, that if it drop on the hand it raises a blister.

The American plant lobelia longiflora produces a suffocating oppression in the breast of those who respire in its vicinity, according to Jacquin, Hortus Vindobonensis. The rhus toxicodendron emits so dangerous an exhalation, that Ingenhousz attributes the return of a periodical disorder, which attacked the family of the curate of Crossen in Germany, to a bench shaded by this tree, under which they had the custom of sitting. Every one knows the effects of musk and oriental saffron on certain persons; and the exhalation of the walnut-tree is considered as very unwholesome.

We may here mention the noxious property of those canes or reeds which in this country are used to cover roofs and dunghills, &c. Mr. Poitiven saw a man who was very ill on account of having handled these canes: the parts of generation were prodigiously swelled. A dog which had slept upon the reeds suffered in the same manner, and was affected in the same parts.

The method of extracting the aroma varies according to its volatility and affinities. It is in general soluble in

water, alcohol, oils, &c. and these fluids are severally employed to extract it from plants which afford it.

When water or alcohol are used, they are distilled by a gentle heat, and the aroma comes over with them. Simple infusion may be used; and in this way the loss of a portion of the aroma is avoided.

Water charged with aroma is known by the name of the distilled water of the substance made use of. The distilled water of inodorous or herbaceous plants does not appear to possess any virtue; and the apothecaries have long since decided the question, by substituting spring water in its place. Spirit of wine combined with the same principle, is known by the name of the spirit or quintessence of the vegetable.

When the aroma is very fugacious, such as that of lilies, jasmine, or tuberose, the flowers are put into a tin cucurbit with cotton steeped in oil of ben. The cotton and the flowers are disposed in alternate layers; the cucurbit is closed, and a gentle heat applied. In this manner the aroma is permanently combined with the oil.

These are the three methods used to retain the odorant principle. The art of the perfumer consists in applying them at pleasure to various substances.

Perfumes are either dry or liquid. Among the first we may place the sachets, or little perfumed bags, which contain either mixtures of aromatic plants, or aromas in their native state; the perfumed powders, which obtain their smell by a few drops of the solution of aroma; the pastilles or comfits which have sugar for their basis, &c.

Liquid perfumes most commonly consist of aroma dissolved in water or alcohol; the various liqueurs, or scented spirituous cordial waters, are nothing else but the same solutions diluted with water, and sweetened with sugar.

For example, to make the eau divine, the bark of four citrons is taken, and put into a glass alembic, with two pounds of good spirit of wine, and two ounces of good orange-flower water; after which, distillation is performed on the sand-bath. On the other hand, one pound and a half of sugar is dissolved in one pound and a half of water. The two liquors being mixed, become turbid; but, being left to stand, the result is an agreeable liquor.

To make the cream of roses, I take equal parts of rose water, spirit of wine à la rose, and syrup of sugar. I mix these three substances, and colour the mixture with the infusion of cochenille.

But it must be allowed that, in all perfumes which are a little complicated, the nose is the best chemist that can be consulted ; and a good nose is as requisite and essential to a perfumer, as a strong head is to a geometer.

SECT. V.

Concerning the Alterations to which Vegetables are subject after they are deprived of Life.

THE same principles which maintain life in vegetables and animals, become the speediest agents of their destruction when dead. Nature seems to have entrusted the composition, maintenance, and decomposition of these beings to the same agents. Air and water are the two principles which maintain the life in living beings ; but the moment they are dead they hasten their alteration and dissolution. The heat itself, which assisted and fomented the functions of life, concurs to facilitate the decomposition. Thus it is that the frosts of Siberia preserve bodies for several months; and that in our mountains they are kept for a long time on the snow, when it intercepts the carrying them to the place of interment.

We shall examine the action of these three agents, namely, heat, air, and water ; and we shall endeavour to shew the power and effect of each before we shall attend to their combined action.

CHAP. I.

Concerning the Action of Heat upon Vegetable Substances.

THE distillation of plants by a naked fire is nothing but the act of decomposing them by means of simple heat. This process was for a long time the only method of analysis. The first chemists of Paris adopted it for the analysis of near one thousand four hundred plants: and it was not till the commencement of the present century that this labour was discontinued; a labour which did not seem to advance the science, since in this way the cabbage and hemlock afforded the same products.

It is clear that an analysis by the retort ought not to shew the principles of vegetation: for, not to mention that heat changes their nature by becoming a constituent part of the principles extracted; these principles themselves become mixed together, and we can never know their order or state while in the living plant. The action of the heat moreover causes the vegetable principles to react upon each other, and confounds the whole together. Whence it arises that all vegetables afford nearly the like principles; namely, water, an oil more or less thick, an acid liquor, a concrete salt, and a coal or caput mortuum more or less abundant.

Hales took notice that the distillation of vegetables afforded much air; and was even in possession of an apparatus to collect and measure it. But in our time the methods of collecting and confining the gases are simplified; and the hydro-pneumatic apparatus has proved that the substances are formed of a mixture of carbonic acid, hydrogene, and sometimes a little nitrogene.

The order in which the several products are obtained, and the characters they exhibit, lead us to the following observations:

1. The water which passes first is usually pure, and without smell; but when odorant plants are distilled, the first drops are impregnated with their aroma. These first portions of water consist of that which was superabun-

dant, and impregnated the vegetable tissue. When the water of composition, or that which was in combination with the vegetable, begins to rise, it carries along with it a small quantity of oil, which colours it ; and some portions of a weak acid, afforded by the mucilage and other principles with which it existed in the saponace-ous state. The phlegm likewise very often contains a small quantity of ammoniae : and this alkali appears to be formed in the operation itself; for there are few plants which contain it in their natural state.

2. To the phlegm succeeds an oily principle, little co-loured at first; but in proportion as the distillation ad-vances, the oil which rises is thicker, and more coloured. They are all characterized by a smell of burning, and an acrid taste, that arise from the impression of the fire it-self. These oils are most of them resinous, and the ni-tric acid easily inflames them. They may be rendered more fluid and volatile by repeated distillations.

3. In proportion as the oil comes over, there sometimes distils carbonate of ammoniac, which attaches itself to the sides of the vessels. It is usually soiled with an oil which colours it. This salt does not appear to exist ready form-ed in vegetables. Rouelle the younger proved that the plants which afford the most of it, such as the cruciferous plants, do not contain it in their natural state. It is there-fore found when its component parts are volatilized and reunited by the distillation.

4. All vegetables afford a very great quantity of gas by distillation ; and their nature has an influence on the gase-ous substances they afford. Those plants which abound with resin, afford much more hydrogenous gas ; while such as abound with mucilage produce carbonic acid.

The mixture of these gases forms an air which is hea-vier than the common inflammable air, on which account it has been found very little adapted to aerostatic experi-ments.

The art of charring wood, or converting it into char-coal, is an operation nearly similar to the distillation we have just described. It consists in forming pyramids of wood, or cones truncated at their summit. The whole is covered with earth, well beaten, leaving a lower and up-per aperture. The mass is then set on fire ; and when the

whole is well ignited, the combustion is stopped by clos-
ing the apertures through which the current of air passed.
By this means the water, the oil, and all the principles of
the vegetable, are dissipated, except the fibre.   The
wood in this operation loses three-fourths of its weight,
and one-fourth of its bulk.   According to Fontana and
Morozzo, it absorbs air and water as it cools.   I am
assured, from my experiments in the large way, that pit-
coal desulphurated (coaked) acquires twenty-five pounds
of water in the quintal by cooling; but the coal of wood
did not appear to me to absorb more than fifteen or twen-
ty.   The suturbrand of the Icelanders is nothing but
wood converted into charcoal by the lava which has sur-
rounded it.—See Von Troil's Letters on Iceland.

The charcoal which is the residue of all these distilla-
tions, is a substance which deserves an attention more
particularly because it enters into the composition of ma-
ny bodies, and bears a very great part in their pheno-
mena.

Charcoal is the vegetable fibre very slightly changed.
It most commonly preserves the form of the vegetable
which afforded it.   The primitive texture is not only dis-
tinguishable, but serves likewise to indicate the state and
nature of the vegetable which has afforded it.   It is some-
times hard, sonorous, and brittle; sometimes light, spongy,
and friable ; and some substances afford it in a subtile
powder, without consistence.   The coal of oils and resins
is of this nature.

Charcoal well made has neither smell nor taste ; and it
is one of the most indecomposable substances we are ac-
quainted with.

When dry, it is not changed by distillation in close
vessels.   But, when moist, it affords hydrogenous gas and
carbonic acid; which proves the decomposition of the wa-
ter, and the combination of one of its principles with the
charcoal, while the other is dissipated.   By successively
moistening and distilling charcoal, it may be totally de-
stroyed.

Charcoal combines with oxigene, and forms the carbo-
nic acid ; but this combination does not take place unless
their action be assisted by heat.   The charcoal which
burns in a chafing-dish exhibits this result ; and we per-

ceive two very immediate effects in this operation :—1.
A disengagement of heat, afforded by the transition of the
oxigenous gas to the concrete state.   2. A production of
carbonic acid : it is the formation of this acid gas which
renders it dangerous to burn charcoal in places where the
current of air is not sufficiently rapid to carry off the car-
bonic acid as it is formed.

Well-made charcoal does not change by boiling in wa-
ter.   In process of time it gives a slight reddish tinge to
that fluid, which arises from the solution of the coaly re-
sidue of the oils of the vegetable mixed with the coaly
residue of the fibre.

If the sulphuric acid be digested upon charcoal, it is
decomposed ; and affords carbonic acid, sulphureous acid,
and sulphur.

The nitric acid, when concentrated, is decomposed
with much greater rapidity ; for if it be poured upon very
dry powder of charcoal, it sets it on fire.   This inflamma-
tion may be facilitated by heating the charcoal or the acid.
If the fluid which arises in this experiment be collected,
it is found to be carbonic acid, nitrous gas, and nitric
acid.   M. Proust has observed, that when the acid is
poured into the middle of the charcoal, it does not take
fire ; but that this effect immediately succeeds if the acid
be suffered to flow beneath the coal.   It may even be in-
flamed by throwing it upon the nitric acid slightly heated.

If weak nitric acid be digested upon charcoal, it dis-
solves it, assumes a red colour, becomes pasty, and ac-
quires a bitter disagreeable taste.

Charcoal, mixed with the sulphuric and nitric salts, de-
composes them ; when combined with oxides, it revives
the metals.   All these effects depend on its very great af-
finity with the oxigene contained in these bodies.   It is
used to facilitate the decomposition of salt-petre in some
cases, as in the composition of gun-powder, the black
flux, &c.

Rouelle has observed that the fixed alkali dissolves a
good quantity of charcoal by fusion.   The same chemist
has discovered that the sulphure of alkali dissolves it in
the humid as well as the dry way.

Charcoal is likewise capable of combining with metals.
It combines with iron in its first fusion, and mixes with

it likewise in the cementation by which steel is formed. When combined with iron in a small proportion of the metal, it constitutes plumbago. It is likewise capable of combining with tin by cementation; to which metal it gives brilliancy and hardness, as I find by experiment.

CHAP. II.

Concerning the Action of Water singly applied to Vegetables.

WE may consider the action of water upon vegetables in two very different points of view. Either the chemist applies this fluid to the plant itself, to extract and separate the juices from the ligneous part: or else the plant itself, being immersed in this fluid, is from this time delivered to its single action; and in that situation becomes gradually changed and decomposed in a peculiar manner. In these two cases, the products of the operations are very different. In the first the ligneous texture remains untouched, and the juices which are separated remain unchanged in the fluid: in the second, more especially when vegetables ferment in heaps, the nature of the juices is partly changed, but the oils and resins remain confounded with the ligneous tissue; so that the result is a mass in which the disorganized vegetable is seen in a state of mixture and confusion of the various principles which compose it.

The chemist applies water to vegetables, to extract their juices, according to two methods, which constitute infusion and decoction.

Infusion is performed by pouring upon a vegetable a sufficient quantity of hot water to dissolve all its principles. The temperature of the water must be varied according to the nature of the plant. If its texture be delicate, or the aroma very fugacious, the water must be slightly heated; but boiling water may be used when the texture is

hard and solid, and more especially when the plant has no
smell.

Decoction, which consists in boiling water with the ve-
getable, ought not to be employed but with hard and ino-
dorous plants. This method is rejected by many che-
mists; because they affirm that, by thus tormenting the
plant, a considerable quantity of fibrous matter becomes
mixed with the juices. Decoction is generally banished
from the treatment of odorant plants, because it dissipates
the volatile oil and aroma. The decoction used in our
kitchens to prepare leguminous plants for food, has the in-
convenience of extracting all the nutritive parts, and
leaving only the fibrous parenchyma. Hence arises the
advantage of the American pot or boiler in which the
garden-stuff is boiled by simple vapour, and consequently
the nutritive principle remains in the vegetable; to which
advantage we may add that of using any water whatever,
because the steam alone is applied to the intended purpose.

But the infusion, decoction, and clarification of juices,
is not left to the choice of the chemist, when it is re-
quired to prepare any medicine; for these methods pro-
duce surprising varieties in the virtue of remedies. Thus,
for example, according to Storck, the concentrated juice
of hemlock has no good qualities unless it be evaporated
without being clarified.

In treating juniper berries by infusion, and evaporation
on a water bath to the consistence of honey, an aromatic
extract is obtained, of a saccharine colour: the decoction
of the same berries affords a less fragrant and less resinous
extract, because the resin separates from the oil, and falls
down.

The extract of grapes, which is called *resiné* in France,
and most sweetmeats, are prepared in this way.

Extracts are prepared in the large way for sale by the
assistance of water. We shall confine ourselves to speak
of two only, the juice of liquorice and of cachou. The
first will afford an example of decoction, and the second of
infusion.

The extract of liquorice is prepared in Spain by decoc-
tion of the shrub of the same name. This plant grows
abundantly near our ponds; and we might at a small ex-
pence avail ourselves of this species of industry: I have

ascertained that a pound of this root affords two or three ounces of good extract. The apothecaries afterwards prepare it in various ways for their several purposes, and to render its use more convenient and agreeable.

The cachou is extracted in the East-Indies from an infusion of the seeds of a kind of palm. While the seed is yet green, it is cut, infused in hot water ; and this infusion is evaporated to the consistence of an extract, which is afterwards made into lumps, and dried in the sun. M. de Jussieu communicated to the Academy, in the year 1720, remarks by which he ascertains that the differences in the several kinds of cachou arise from the various degrees of maturity in the seeds, and the greater or less quickness with which the extract is dried.

The cachou of commerce is usually impure ; but it may be cleared of its impurities by dissolving, filtering, and evaporating it several times.

The taste of cachou is bitter and astringent. It dissolves very well in the mouth, and is used as a restorative for weak stomachs : it is made into comfits by the addition of three parts of sugar, and a sufficient quantity of gum adragant.

When vegetables are immersed in water, their texture becomes relaxed ; all the soluble principles are carried off; and there remains only the fibrous part disorganized, and impregnated with vegetable oil, altered and hardened by the reaction of other principles. This transition may be very well observed in marshes, where plants grow and perish in great numbers, forming mud by their decomposition. These strata of decomposed vegetables, when taken out of the water and dried, may be used as the material of combustion. The smell is unwholesome; but in shops, or places where the chimneys draw well, this combustible may be used.

Vegetables have been considered as the cause of the formation of pit-coal ; but a few forests being buried in the earth are not sufficient to form the mountains of coal which exist in its bowels. A greater cause, more proportioned to the magnitude of the effect, is required; and we find it only in that prodigious quantity of vegetables which grow in the seas, and is still increased by

the immense mass of those which are carried down by rivers. These vegetables, carried away by the currents, are agitated, heaped together, and broken by the waves; and afterwards become covered with strata of argillaceous or calcareous earth, and are decomposed. It is easier to conceive how these masses of vegetables may form strata of coal, than that the remains of shells should form the greater part of the globe.

The direct proofs which may be given of the truth of this theory are—

1. The presence of vegetables in coal mines. The bamboo and bannana trees are found in the coal of Alais. It is common to find terrestrial vegetables confounded with marine plants.

2. The prints of shells and of fish are likewise found in the strata of coal, and not unfrequently shells themselves. The pit-coal of Orsan and that of Saint-Esprit contain a prodigious number.

3. It is evidently seen, by the nature of the mountains which contain charcoal, that their formation has been submarine; for they all consist either of schistus, or grit, or limestone. The secondary schistus is a kind of coal in which the earthy principle predominates over the bituminous. Sometimes even this schistus is combustible, as is seen in that of St. George near Milhaud. The texture of the vegetables, and the impression of fish, are very well preserved in the schistus. The origin of the schistus is therefore submarine; and consequently so likewise must be the origin of the coal distributed in strata through its thickness.

The grit-stone consists of sand heaped together, carried into the sea by the rivers, and thrown up against the shores by the waves. The strata of bitumen which are found in these cannot therefore but come from the sea.

Calcareous earth rarely contains strata of coal, but is merely impregnated with it, as at St. Ambroise, at Servas, &c. where the bitumen forms a cement with the calcareous earth.

Concerning Pit-Coal.*

Pit-coal is usually found in strata in the earth, almost always in mountains of schistus or grit. It is the property of coal to burn with flame, and the emission, of much smoke.†

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* A peculiar kind of coal is found in immense quantities, in Pennsylvania, in the county of Northampton, near the river Lehigh It is of a shining black colour, and stains the hands very little. Its fragments are tabular, as may be seen, particularly after it has been submitted to heat. Its specific gravity is 1.6 81. It burns with very little flame, and no smoke; is with some difficulty kindled, and requires a considerable draught of air, to keep up its combustion.

When perfectly consumed, it leaves behind a small portion of white siliceous earth, containing no potash, and sometimes coloured brown, by means of iron. It does not contain any sulphur.

Neither the sulphuric, nitric, nor muriatic acids act upon it.

It does not take fire, when reduced to an impalpable powder, and passed through the flame of a candle.

A piece of it red hot, containing about eight cubic inches, was placed in forty-eight ounce measures of atmospheric air over water, and suffered to cool. Upon passing one measure of this air over lime water, in the Eudiometer of Fontana, it gave one per cent. of carbonic acid gas The remainder of the air, after being freed from the fixed air, was reduced in purity from 100 to 85.

One cubic inch of it, red hot, suspended in ten ounce measures of oxigene gas, brightened very little.

The focus of an eleven-and-a-half inch lens, was directed upon a lump of it, confined in a bell-glass, in twelve ounce measures of oxigene gas, over water, when it burnt with a considerable flame, and nearly in the same manner, as the James's river coal, when a blast of atmospheric air is thrown upon it. The gas was afterwards reduced in purity, and contained fifty per cent. of carbonic acid gas.

A quantity of the coal red hot, being extinguished under water, produced an inflammable air, without any mixture of fixed air.

Two measures of this gas, and one of oxigene air exploded by the electric spark, in the Eudiometer of Volta, left behind one measure of

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† This is by no means the case, as the coal described above burns with little flame, and no smoke.—*Am. Ed.*

The secondary schistus is the basis of all pit-coal, and the quality of the coal mostly depends upon the proportion of this basis. When the schistus predominates, the coal is heavy, and leaves a very abun-

hydrogen gas, containing ten per cent of carbonic acid gas. Two measures of each of the gases, by the same means were reduced to something more than a measure of oxigene air, which was mixed with fifteen per cent. of fixed air.

Four ounces of it, reduced to a coarse powder, were exposed in an earthen retort. to a red heat in one of Lewis's black lead furnaces, when it yielded three hundred and sixty ounce measures of hydrogen gas, of the same kind as that produced by extinguishing it, when red hot, under water

The same coal taken from the retort, and sprinkled with water, and exposed a second time to heat, afforded thirty ounce measures of inflammable air, in the first portions of which, the carbonic acid was barely perceptible.

The steam of water was transmitted over the coal red hot. confined in a porcelain tube. and it gave hydrogene gas in torrents, mixed with ten per cent. of fixed air. Two measures of this hydrogene gas, after the carbonic acid had been separated from it, and one of oxigene gas, exploded in the eudiometer of solta left near a measure of inflammable air, mixed with fifty per cent. of fixed air.

A fire was kindled at half past eleven o'clock, by placing a quantity of the Lehigh coal. upon a stratum of common charcoal in a powerful air furnace, which was then filled with equal portions of the two substances.

As fast as the charcoal consumed. the Northampton coal was added, and at half past one, the furnace was completely filled with it, and two-thirds of it red hot. At four the coal was half consumed, and it continued burning until eleven o'clock at night.

Five of Wedgwood's thermometer pieces. put in crucibles made of porcelain, were deposited in different places among the coal, that they mi ht descend in different directions, and some of them be exposed to the greatest degree of heat.

When they were cool, being measured by the guage, they gave 70, 77, 150, 156. and 159, degrees.

125 is the hi hest heat Mr. Wedgwood could ever produce, in a common smith's forge, and 160 in an air furnace, eight inches square. Brass melts at twenty-one, copper at twenty-seven, silver at twenty-eight gold at thirty-two, and cast iron at one hundred and thirty of this thermometer. The welding heat of iron is one hundred and twenty-five.[*]

James's river coal. submitted to an experiment of the same kind, burned out in four hours.

* Description and use of a thermometer for measuring the higher degrees of heat, by Josiah Wedgwood. Phil. Trans. Vol. 72nd.

dant earthy residue after its combustion. This kind
of coal is veined internally with flat pieces, or rather
separate masses, of schistus nearly pure, which we call
fiches.

As the formation of the pyrites, as well as that of
coal, arises from the decomposition of vegetable and ani-
mal substances, all pit-coal is more or less pyritous ; so
that we may consider pit-coal as a mixture of pyrites,
schistus, and bitumen. The different qualities of coal

A fire was made with the Lehigh coal, in a Smith's forge, and two
thick bars of iron were placed in it, and welded with great ease, by
the proprietor of the furnace.

The Smith, his journeymen, and bystanders were convinced, that
the heat was much cleaner and greater, than that of the James's
river coal.

As the Virginia coal burns with flame and much smoke, a vast por-
tion of this combustible substance, and the heat generated by it, is
lost by passing up the chimney.

It appears from some of these experiments, that this coal does
not unite to the base of oxigene gas, with as much rapidity as com-
mon charcoal, and that it decomposes water. Its flame consisting
of oxide of carbone, or carbonated hydrogene gas arises from this de-
composition.

When it is exposed to a red heat, and contains little water, it gives
rise to a peculiar species of inflammable air, without any fixed air ;
but when the steam of water is transmitted over it, in a red heat,
the production of carbonic acid gas is very considerable, and when
the hydrogene gas, thus obtained, is fired with oxigene gas, the fixed
air generated amounts to thirty-five per cent. more than when it is
procured from coal united to a small quantity of water.

According to the opinions, now generally adopted by the
Philosophers of Europe, the gases, when little water is mix-
ed with the coal, must consist of oxide of carbone and carbonated
hydrogene gas. It will be said, the oxigene of the water, unites
to part of the coal, and forms oxide of carbone, while its hydrogene
escapes, dissolves a portion of the coal, and makes carbonated hydro-
gene gas.

This explanation is far from being satisfactory ; for no oxide of
carbone can be detected in the gases, produced by extinguishing this
coal when red hot under water, or by submitting it to a heat in an
earthen retort.

The Lehigh coal promises to be particularly useful, where a
long continued heat is necessary, as in distilling, or in evaporating
large quantities of water from various substances ; in the melting of
metals, or in subliming of salts ; in generating steam to work steam
engines ; and in common life, for washing, cooking, &c. *provided the
fire-places are constructed in such a manner, as to keep up a strong
draught of air.*—*Am. Ed.*

arise therefore from the difference in the proportions of these principles.

When the pyrites is very abundant, the coal exhibits yellow veins of the mineral, which are decomposed as soon as they come in contact with the air; and form an efflorescence of sulphate of magnesia, of iron, of alumine, &c.

When pyritous coal is set on fire, it emits an insupportable smell of sulphur; but when the combustion is insensible, inflammation is frequently produced by the decomposition of the pyrites; and it is this which occasions the inflammation of several veins of coal. There are veins of coal on fire at St. Etienne in Forez, at Cramsac in Rouergue, at Roquecremade in the diocese of Beziers; and it is not rare to see the fire destroy considerable masses of pyritous coal, when the decomposition is favoured by the concurrence of air and water. If the inflammation be excited in more considerable masses of bitumen, the effects are then more striking; and it is to a cause of this nature that we ought to refer the origin and effect of volcanos.

When the schistus, or slaty principle, predominates in coals, they are then of a bad quality, because their earthy residue is more considerable.

The best coal is that in which the bituminous principle is the most abundant, and exempt from all impurity. This coal swells up when it burns, and the fragments adhere together: it is more particularly upon this quality that the practice of the operation called desulphurating or purifying of coal depends. This operation is analogous to that in which wood is converted into charcoal. In the desulphuration, pyramids are made, which are set on fire at the centre. When the heat has strongly penetrated the mass, and the flame issues out of the sides, it is then covered with moist earth; the combustion is suffocated, the bitumen is dissipated in smoke, and there remains only a light spongy coal, which attracts the air and humidity, and exhibits the same phenomena in its combustion as the coal of wood. When it is well made, it gives neither flame nor smoke; but it produces a stronger heat than than that of an equal mass of native coal. This

operation received the name of desulphurating (desou-frage) from a notion that the coal was by this means de-prived of its sulphur ; but it has been proved that all coals which are capable of this operation, contain scarcely any sulphur.

It was for a long time supposed that the smell of pit-coal was unwholesome; but the contrary is now prov-ed. Mr. Venel has made many experiments on this subject, and is convinced that neither man nor ani-mals are incommoded by this vapour. Mr. Hoffman relates that disorders of the lungs are unknown in the vil-lages of Germany, where this combustible only is used. I think that coal of a good quality does not emit any dan-gerous vapour : but when it is pyritous its smell cannot but be hurtful.

The use of coal is generally applicable to the arts ; and nature appears to have concealed these magazines of com-bustible matter, to give us time to repair our exhausted forests. These mines are very abundant and numerous in the kingdom of France. Our province contains many, and we have more than twenty which are in full work. Pit-coal is applied in England even to domestic uses, and this part of mineralogy is very much cultivated in that kingdom. Individuals have there undertaken the most considerable enterprizes in this way. The Duke of Bridgewater has made a canal, at Bridgewater, two thou-sand five hundred toises in length, to facilitate the working of the coal mines in Lancashire. It cost five millions of livres: part of it is carried under a mountain ; and it pass-es successively under as well us over rivers and highways. In our province we are in want of roads only for the trans-portation of our coal ; and Languedoc has not had the spirit to perform a work which a private individual has ex-ecuted in England.

In Scotland, Lord Dundonald has erected furnaces in which the bitumen is disengaged from coal ; and the va-pours are received and condensed in chambers, over which he has caused a river to flow for the purpose of cooling them. These condensed vapours supply the En-glish navy with as much tar as it requires. Becher, in his work intitled " Foolish Wisdom, or Wise Folly,"

printed at Frankford in 1683, affirms that he succeeded in appropriating the bad turf of Holland, and the bad coal of England, to the common uses. He adds that he obtained tar superior to that of Sweden by a process similar to that of the Swedes. He affirms that he had made this known in England, and shewn it to the King.

Mr. Faujas has carried the process of the Scotch nobleman into execution at Paris. The whole consists in setting fire to the coal, and extinguishing it at the proper time, that the vapour may pass into chambers containing water for the purpose of condensing them. This tar appeared to be superior to that of wood.

Pit-coal likewise affords ammoniac by distillation, which is dissolved in water, while the oil floats above.

When coal is deprived by combustion of all the oil and other volatile principles, the earthy residue contains the sulphates of alumine, iron, magnesia, lime, &c. These salts are all formed when the combustion is slow; but when it is rapid the sulphur is dissipated, and there remain only the aluminous, magnesian, calcareous, and other earths. The alumine most commonly predominates.

Naptha, petroleum, mineral pitch, and asphaltes, are only slight modifications of the bituminous oil so abundant in pit-coal. This oil, which the simple heat of the decomposition of the pyrites is sufficient to disengage from the coal, receives other modifications by the impression of the external air.

Petroleum, or the oil petrol, is the first alteration. This oil is found near volcanos, in the vicinity of coal mines, &c. We are acquainted with several springs of this petroleum. There is one at Gabian in the diocese of Beziers. It is carried out by the water of a spring which issues from the lower part of a mountain whose summit is volcanized.

The smell of petroleum is disagreeable: its colour is reddish; but it may be rendered clear by distilling it from the clay of Murviel.

Naptha is merely a variety of petroleum.

Near Derbens, on the Caspian Sea, there are springs of naptha, which Kempfer visited about a century ago, and of which he has left a description.

There is a place known by the name of the Perpetual
Fire, where the fire burns without ceasing. The Indians
do not attribute the origin of this inextinguishable fire to
naptha; but they maintain that God has confined the De
vil in this place, to deliver man from him. They go in
pilgrimage thither, and make their prayers to God that he
will not suffer this enemy of mankind to escape.

The earth impregnated with naptha is calcareous, and
effervesces with acids; it takes fire by the contact of any
ignited body whatever.

This perpetual fire is of great use to the inhabitants of
Baku. They pare off the surface of this burning soil,
upon which they make a heap of limestones, and cover it
with the earth pared off; and in two or three days the lime
is made.

The inhabitants of the village of Frogann repair to this
place to cook their provisions.

The Indians assemble from all parts to adore the Eter-
nal Being in this place. Several temples were built, one
of which is still in existence. Near the altar there is a
tube inserted in the earth, two or three feet in length;
out of which issues a blue flame, mixed with red. The
Indians prostrate themselves before this tube, and put
themselves into attitudes which are exceedingly strange
and painful.

Mr. Gmelin observes that two kinds of naptha are dis-
tinguished in this country; the one transparent and yel-
low, which is found in a well. This well is covered with
stones smeared with a cement of fat earth, in which the
name of Kan is engraved; and no one is permitted to
break this sealed covering but those who are deputed from
the Kan.

Mineral pitch is likewise a modification of petroleum.
It is found in Auvergne, at a place called Puits de La-
pege, near Allais, in an extent of several leagues, which
comprehends Servas, Saint Ambroix, &c.

The calcareous stone is impregnated with a bitumen
which is softened by the heat of summer, when it flows
from the rocks, and forms a very beautiful stalactites. It
forms masses in the fields, and impedes the passage of
carriages : the peasants use it to mark their sheep. This
stone emits an abominable smell when rubbed. The epis-

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copal palace of Alais was paved with it in the time of Mr. Davejan; but it became necessary to substitute other stone in its stead. It is asserted that mineral pitch was used to cement the walls of Babylon.

Asphaltes, or bitumen Judaicum, is black, brilliant, ponderous, and very brittle.

It emits a smell by friction; and is found floating on the water of the lake Asphaltites, or the Dead Sea.

The asphaltes of commerce is extracted from the mines of Annemore, and more particularly in the principality of Neufchatel. Mr. Pallas found springs of asphaltes on the banks of the Sock, in Prussia.

Most naturalists consider it as amber decomposed by fire.

Asphaltes liquefies on the fire, swells up, and affords flame, with an acrid disagreeable smoke.

By distillation it affords an oil resembling petroleum. The Indians and Arabs use it instead of tar, and it is a component part of the varnish of the Chinese.

Yellow amber, karabe, or the electron of the ancients, is in yellow or brown pieces, transparent or opaque, capable of a polish, becoming electric by friction, &c.

It is friable and brittle.

There is no substance on which the imagination of poets has been more exercised than this. Sophocles had affirmed that it was formed in India by the tears of the sisters of Meleager, changed into birds, and deploring the fate of their brother; but one of the most interesting fabulous origins which have been attributed to it, is afforded by the fable of Phaeton burning the heavens and the earth, and precipitated by the thunder of Jove into the waters of Eridanus. His sisters are described weeping; and the precious tears fell into the waters without mixing with them, became solid without losing their transparency, and were converted into the yellow amber so highly valued by the ancients.—See Bailly.

Amber possesses less coaly matter than any other bitumen.

It is frequently found dispersed over strata of pyritous earth, and covered with a stratum of wood, abounding with a blackish bituminous matter.

It is found floating in the Baltic Sea, on the coast of Ducal Prussia; it is also found near Sistreron in Provence.

No other chemical use was for a long time made of amber, than to form compositions for medicine and the arts. We are indebted to Neumann, Bourdelin, and Pott for a tolerably accurate analysis of this bitumen. The two constituent principles exhibited in the analysis of amber, are the salt of amber, or succinic acid, and a bituminous oil.

To extract the succinic acid, the amber is broken into small pieces, which are put into a retort, and distilled with a suitable apparatus upon a sand-bath. When the fire is carefully managed, the products are—1. An insipid phlegm. 2. Phlegm holding a small portion of acid in solution. 3. A concrete acid salt, which attaches itself to the neck of the retort. 4. A brown and thick oil, which has an acid smell.

The concrete salt always retains a portion of oil* in its first distillation. Scheffer, in his Lessons of Chemistry, proposes to distil it with sand; Bergmann with white clay; Pott advises solution in water, and filtration through white cotton; after which the fluid is to be evaporated, and is found to be deprived of the oil, which remains on the cotton. Spielmann, after Pott, proposes to distil it with the muriatic acid; it then sublimes white and pure. Bourdelin clears it of its oil by detonation with nitre. This salt is prepared in the large way at Koningsberg, where the shavings and chips of amber are distilled.

The succinic acid has a penetrating taste, and reddens the tincture of turnsol. Twenty-four parts of cold water, and two of boiling water, dissolve one of this acid. If a saturated solution of this salt be evaporated, it crystallizes in triangular prisms, whose points are truncated.

Mr. De Morveau observes that its affinities are barytes, lime, alkalis, magnesia, &c.

The oil of amber has an agreeable smell: it may be deprived of its colour by distillation from white clay. Rouelle distilled it with water. When mixed with ammoniac it forms a liquid soap, known by the name of Eau de Luce.

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* *Acide* in the original: doubtless by oversight. T.

To make eau de luce I dissolve Punic wax in alcohol,
with a small quantity of oil of amber ; and on this I pour
the pure volatile alkali.

Alcohol attacks amber, and acquires a yellow colour.
Hoffmann prepares this tincture by mixing the spirit of
wine with an alkali.

The medical use of amber consists in burning it, and
receiving the vapour on the diseased part. These vapours
are strengthening, and remove obstructions. The oil of
amber is applied to the same use. A syrup of amber is
made with the spirit of amber and opium, which is used
to advantage as a sedative anodyne medicine. The finest
pieces of amber are used to make toys. Wallerius af-
firms that the most transparent pieces may be used to
make mirrors, prisms, &c. It is said that the King of
Prussia has a burning mirror* of amber one foot in dia-
meter ; and that there is a column of amber in the cabinet
of the Duke of Florence ten feet high, and of a very fine
lustre.

Concerning Volcanos.

The combustion of those enormous masses of bitumen
which are deposited in the bowels of the earth, produces
volcanos. They owe their origin more especially to the
strata of pyritous coal. The decomposition of water upon
the pyrites determines the heat, and the production of a
great quantity of hydrogenous gas, which exerts itself
against the surrounding obstacles, and at length breaks
them. This effect is the chief cause of earthquakes ; but
when the concourse of air facilitates the combustion of
the bitumen and the hydrogenous gas, the flame is seen to
issue out of the chimneys or vents which are made : and
this occasions the fire of volcanos.

There are many volcanos still in an active state on our
globe, independent of those of Italy, which are the most
known. The able Chappe has described three burning

* So in the original ; but the matter as well as the properties of
this substance put it out of doubt that it should be *lens*. T.

in Siberia. Anderson and Von Troil have described those of Iceland. Asia and Africa contain several : and we find the remains of these fires or volcanic products in all parts of the globe.

Naturalists inform us that all the southern islands have been volcanized ; and they are seen daily to be formed by the action of these subterraneous fires. The traces of fire exist even immediately around us. The single province of Languedoc contains more extinct volcanos than twenty years ago were known to exist through all Europe. The black colour of the stones, their spongy texture, the other products of fire, and the identity of these substances with those of the volcanos at present burning, are all in favour of the opinion that their origin was the same.*

* A volcano was announced and described to be burning in Languedoc, respecting which it is necessary to give some elucidation. This pretended volcano is known by the name of the Phosphorus of Venejan

Venejan is a village situated at the distance of a quarter of a league from the high road between St. Esprit and Bagnols. From time immemorial, at the return of spring, a fire was seen from the high road, which increased during the summer, was gradually extinguished in autumn, and was visible only in the night. Several persons had at various times directed their course from the high road, in a right line towards Venejan, to verify the fact upon the spot : but the necessity of descending into a deep valley before they could arrive thither, occasioned them to lose sight of the fire ; and on their arrival at Venejan no appearance was seen in the least resembling the fire of a volcano. Mr. de Genssane describes this phenomenon, and compares it to the flashing of a strong aurora borealis : he even says that the country is volcanic. Hist. Nat. du Languedoc, Diocese de'Uzes.—At length, in the course of the last four or five years, it was observed that these fires were multiplied in the spring ; and that, instead of one, there were three. Certain philosophers of Bagnols undertook the project of examining this phenomenon more closely ; and for this purpose they repaired to a spot between the high road and Venejan, armed with torches, speaking trumpets, and every other implement which they conceived to be necessary for making their observations. At midnight, four or five of the party were deputed and directed towards the fire ; and those who remained behind directed them constantly in their way by means of their speaking trumpets. They at last arrived at the village, where they found three groups of women winding silk in the middle of the street by the light of a fire made of hemp stalks. All the volcanic phenomena then disappeared, and the explanation of the observations made on this subject became very simple. In the spring, the fire was weak, because it was fed with wood, which afforded heat and light ; dur-

When the decomposition of the pyrites is advanced, and the vapours and elastic fluids can no longer be contained in the bowels of the earth, the ground is shaken, and exhibits the phenomena of earthquakes. Mephitic vapours are multiplied on the surface of the ground, and dreadful hollow noises are heard. In Iceland, the rivers and springs are swallowed up: a thick smoke, mixed with sparks and lightning, is then disengaged from the crater; and naturalists have observed that, when the smoke of Vesuvius takes the form of a pine, the eruption is near at hand.

To these preludes, which shew the internal agitation to be great, and that obstacles oppose the issue of the volcanic matters, succeeds an eruption of stones and other products, which the lava drives before it; and lastly appears a river of lava, which flows out, and spreads itself down the side of the mountain. At this period the calm is restored in the bowels of the earth, and the eruption continues without earthquakes. The violent efforts of the included matter sometimes cause the sides of the mountain to open; and this is the cause which has successively formed the smaller mountains which surround volcanos. Montenuovo, which is a hundred and eighty feet high, and three thousand in breadth, was formed in a night.

This crisis is sometimes succeeded by an eruption of ashes which darken the air. These ashes are the last result of the alteration of the coals; and the matter which is first thrown out is that which the heat has half vitrified. In the year 1767, the ashes of Vesuvius were carried twenty leagues out to sea, and the streets of Naples were covered with them. The report of Dion, concerning the eruption of Vesuvius in the reign of Titus, wherein the ashes were carried into Africa, Egypt, and Syria, seems to be fabulous. Mr. de Saussure observes that the soil of

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ing the summer, hemp stalks were burned because light only was wanted. At that time there were three fires, because the fair of Saint Esprit was near at hand, at which they sold their silk, and which consequently put them under the necessity of expediting their work. As these observers announced their arrival with much noise, the country people drove them back by a shower of stones which the Don Quixotes of natural history might have taken for a volcanic eruption.

Rome is of this character, and that the famous catacombs are all made in the volcanic ashes.

It must be admitted, however, that the force with which all these products are thrown, is astonishing. In the year 1769, a stone twelve feet high, and four in circumference, was thrown to the distance of a quarter of a mile from the crater: and in the year 1771, Sir William Hamilton observed stones of an enormous size, which employed eleven seconds in falling.

The eruption of volcanos is frequently aqueous: the water, which is confined, and favours the decomposition of the pyrites, is sometimes strongly thrown out. Sea salt is found among the ejected matter, and likewise sal ammoniac. In the year 1630, a torrent of boiling water, mixed with lava, destroyed Portici and Torre del Greco. Hamilton saw boiling water ejected. The springs of boiling water in Iceland, and all the hot springs which abound at the surface of the globe, owe their heat only to the decomposition of pyrites.

Some eruptions are of a muddy substance; and these form the tufa, and the puzzolano. The eruption which buried Herculaneum is of this kind. Hamilton found an antique head, whose impression was well enough preserved to answer the purpose of a mould. Herculaneum, at the least depth, is seventy feet under the surface of the ground, and often at one hundred and twenty.

The puzzolano is of various colours. It is usually reddish; sometimes grey, white, or green: it frequently consists of pumice-stone in powder; but sometimes it is formed of calcined clay. One hundred parts of red puzzolano afforded Bergmann, silex 55, alumine 20, lime 5, iron 20.

When the lava is once thrown out of the crater, it rolls in large rivers down the side of the mountain to a certain distance, which forms the currents of lava, the volcanic causeways, &c. The surface of the lava cools, and forms a solid crust, under which the liquid lava flows. After the eruption, this crust sometimes remains, and forms hollow galleries, which Messrs. Hamilton and Ferber have visited: it is in these hollow places that the sal ammoniac, the marine salt, and other substances, sublime. A lava may be turned out of its course by opposing banks or

dikes against it : this was done in 1669, to save Catania ; and Sir William Hamilton proposed it to the king of Na- ples, to preserve Portici.

The currents of lava sometimes remain several years in cooling. Sir William Hamilton observed, in 1769, that the lava which flowed in 1766 was still smoking in some places.

When the current of lava is received by water, its cool- ing is quicker ; and the mass of lava shrinks so as to be- come divided into those columns which are called basaltes. The famous Giants Causeway is the most astonishing ef- fect of this kind which we are acquainted with. It exhi- bits thirty thousand columns in front, and is two leagues in length along the sea coast. These columns are be- tween fifteen and sixteen inches in diameter, and from twenty-five to thirty feet long.

The basaltes are divided into columns of four, five, six, and seven sides. The emperor Vespasian made an entire statue, with sixteen children, out of a single column of basaltes, which he dedicated to the Nile, in the temple of Peace.

Basaltes afforded Bergmann, per quintal, silex 56, alu- mine 15, lime 4, iron 25.

Lava is sometimes swelled up and porous. The light- est is called pumice-stone.

The substances thrown out by volcanos are not altered by fire. They eject native substances, such as quartz, crystals of amethyst, agate, gypsum, amianthus, feld- spar, mica, shells, schorl, &c.

The fire of volcanos is seldom strong enough to vitrify the matters it throws out. We know only of the yellow- ish capillary and flexible glass thrown out by the volcanos of the island of Bourbon on the fourteenth of May 1766 (M. Commerson), and the lapis gallinaceus ejected by He- cla. Mr. Egolfrjouson, who is employed by the Obser- vatory at Copenhagen, has settled in Iceland, where he uses a mirror of a telescope which he has made out of the black agate of Iceland.

The slow operation of time decomposes lavas, and their remains are very proper for vegetation. The fertile island of Sicily has been every where volcanized. I ob- served several ancient volcanos at present cultivated ; and

the line which separates the other earths from the volcanic earth, constitutes the limit of vegetation. The ground over the ruins of Pompeia is highly cultivated. Sir William Hamilton considers subterranean fires as the great vehicle used by nature to extract virgin earth out of the bowels of the globe, and repair the exhausted surface.

The decomposition of lava is very slow. Strata of vegetable earth, and pure lava, are occasionally found applied one over the other ; which denote eruptions made at distances of time very remote from each other, since it requires nearly two thousand years before lava receives the plough. An argument has been drawn from this phenomenon to prove the antiquity of the globe : but the silence of the most ancient authors concerning the volcanos of our kingdom, of which we find such frequent traces, proves that these volcanos have been extinguished from time immemorial ; a circumstance which carries their existence to a very distant period. Besides this, several thousand years of connected observations have not afforded any remarkable change in Vesuvius or Etna ; nevertheless, these enormous mountains are all volcanized, and consequently formed of strata applied one upon the other. The prodigy becomes much more striking, when we observe that all the surrounding country, to very great distances, has been thrown out of the bowels of the earth.

The height of Vesuvius above the level of the sea is three thousand six hundred and fifty-nine feet ; its circumference thirty-four thousand four hundred and forty-four. The height of Etna is ten thousand and thirty-six feet ; and its circumference one hundred and eighty thousand.

The various volcanic products are applicable to several uses.

1. The puzzolano is of admirable use for building in the water : when mixed with lime, it speedily fixes itself ; and water does not soften it, for it becomes continually harder and harder. I have proved that calcined ochres afford the same advantage for this purpose ; they are made into balls, and baked in a potter's furnace in the usual manner. The experiments made at Sette, by the commissary of the province, prove that they may be substi-

tuted with the greatest advantage, instead of the puzzo-
lano of Italy.

2. Lava is likewise susceptible of vitrification ; and in
this state it may be blown into opaque bottles of the great-
est lightness, as I have done at Erepian and at Alais.
The very hard lava, mixed in equal parts with wood ashes
and soda, produced an excellent green glass. The bot-
tles made of it were only half the weight of common bot-
tles, and much stronger ; as was proved by my experi-
ments, and those which Mr. Jolly de Fleury ordered to be
made under his administration.

3. Pumice-stone likewise has its uses ; it is more espe-
cially used to polish most bodies which are somewhat hard.
It is employed in the mass or in powder, according to the
intended purpose. Sometimes, after levigation, it is mix-
ed with water to render it softer.

CHAPTER III.

Concerning the Decomposition of Vegetables in the Bow- els of the Earth.

HERBACEOUS plants, buried in the earth, are
slowly decomposed ; but the waters which filter
through and penetrate them relax their texture. The salts
are extracted ; and they become converted into a stratum
of blackish matter, in which the vegetable texture is still
discernible. These strata are sometimes perceived in dig-
ging into the earth. But this alteration is infinitely more
perceptible in wood itself, than in herbaceous plants.
The ligneous body of a tree buried under the ground be-
comes of a black colour, more friable, and breaks short;
the fracture is shining ; and the whole mass appears, in
this state, to form an uniform substance, capable of the
finest polish. The wood thus changed is called Jet.
In the environs of Montpellier, near St. Jean de Cucule,
several cart loads of trunks of trees have been dug up,
whose form was perfectly preserved, but which were con-
verted into jet. I have myself found a wooden peal convert-

ed into jet. In the works at Nismes pieces of wood were found entirely converted into the state of jet. In the neighbourhood of Vachery, in Gevaudan, a jet is found, in which the texture of the walnut tree is very discernible. The texture of the beech is seen in the jet of Bosrup in Scania. In Guelbre a forest of pines has been discovered buried beneath the sand; and at Beichlitz two strata of coal are wrought, according to Mr. Jars, the one bituminous, and the other of fossil wool. I preserve in the cabinet of mineralogy of Languedoc, several pieces of wood whose external part is in the state of jet, while the internal part still remains in the ligneous state; so that the transition from the one to the other may be observed.

Jet is capable of receiving the most perfect polish. It is made into toys, such as buttons, snuff-boxes, necklaces, and other ornaments. It is wrought in Languedoc, near Saint Colombe, at the distance of three leagues from Castelnaudray. It is ground down, and cut into facets, by mills.

Jet softens in the fire, and burns with the emission of a fetid odour. It affords an oil which is more or less black, but may be rendered colourless by repeated distillations from the earth of Murviel.

CHAPTER IV.

Concerning the Action of Air and Heat upon Vegetables.

WHEN the heat is applied to a vegetable exposed to the air, certain phenomena are produced, which depend on the combination of pure air with the inflammable principles of the plant; and this is combustion.

In order to produce a commencement, a heated body is applied to the dry wood which is intended to be set on fire. By this means the principles are volatilized in the same order as we have pointed out in the preceding

article. A smoke is produced, which is a mixture of water, oil, volatile salts, and all the gaseous products which result from the combination of vital air with the several principles of the vegetable. The heat then increases by the combination of the air itself, because it passes to the concrete state: and when this heat is carried to a certain point, the vegetable takes fire, and the combustion proceeds until all the inflammable principles are destroyed.

In this operation there is an absorption of vital air, and a production of heat and light. The combustion will be stronger in proportion as the inflammable principle is more abundant, as the aqueous principle is less abundant, as the wood is more resinous, and as the air is purer and more condensed.

The disengagement of heat and light is more considerable, accordingly as the combination of vital air is stronger in a given time.

The residues of combustion consist of substances which are volatilized, and fixed substances; the one forms the soot, the other ashes.

The soot partly arises from substances imperfectly burned, decomposed only in part, which have escaped the action of vital air. Hence it is that the soot may be burned over again: and hence likewise it is that, when the combustion is very rapid and effectual, there is no perceptible smoke; because all the inflammable matter is then destroyed, as in the cylinder lamps, violent fires, &c.

The analysis of soot exhibits an oil which may be extracted by distillation; a resin which may be taken up by alcohol, and which arises either from the imperfect alteration of the resin of the vegetable, or the combination of vital air with the volatile oil. It likewise affords an acid, which is often formed by the decomposition of mucus; and it is this acid, of great utility in the arts, for which the Academy of Stockholm has described a furnace proper for collecting it. Soot likewise affords volatile salts, such as the carbonate of ammoniac, and others. A slight portion of fibrous matter is likewise volatilized by the force of the fire, and we find it again in the soot.

The fixed principle remaining after combustion, forms the ashes. They contain salts, earths, and metals, of which we have already treated. The salts are fixed alkalis, sulphates, nitrates, muriates, &c. the metals are iron, gold, manganese, &c. and the earths are alumine, lime, silex, and magnesia.

CHAPTER V.

Concerning the Action of Air and Water, which determine a Commencement of Fermentation that separates the Vegetable Juices from the Ligneous Part.

WHEN the decomposition of vegetables is facilitated by the alternate action of air and water, their organization becomes destroyed; the connexion between the various principles is broken; the water carries away the juices; and leaves the fibrous skeleton naked, sufficiently coherent, and sufficiently abundant in certain vegetables, to be extracted in this way. Hemp is prepared in this manner. The abbé Rozier attributes the advantage of watering to the fermentation of the mucilaginous part. M. Prozet has proved that hemp contains an extractive and resinous part; and that the watering destroys the former, and the second is detached almost mechanically. It has been observed that the addition of a small quantity of alkali favours this operation.

Running water is preferable to standing water; because standing water keeps up and develops a stronger fermentation, which attacks the ligneous part. It has been observed that flax prepared in running water is whiter and stronger than that which is prepared in standing water. The stagnant water has likewise the inconvenience of emitting an unpleasant smell, pernicious to the animal

economy. The addition of alkali corrects and prevents this effect.

In the diocese of Lodeve, the young shoots of the Spanish genet are prepared by a very simple process. It is sown on the high grounds, where it is left for three years; at the end of which time the sprigs or young shoots are cut, and formed into bundles, which are sold from twelve to fifteen sous each. The first operation consists in crushing them with a beetle. The following day they are laid in a running stream, with stones upon them, to prevent their being washed away. In the evening they are taken out, and laid in a heap on the banks of the river, upon straw or fern, covering them with the same, and loading the heap with stones: this operation they call *mettre à couvert*. Every evening they throw water on the heap. At the end of eight days they open the mass; and find that the bark is easily separated from the wood. They take the packets, one after the other, and beat and rub them strongly with a flat stone, till the epidermis of the extremities is well cleared off, and the whole stem becomes white. It is then hung to dry; and the bark which was separated from the ligneous substance, is carded and spun, and made into very useful cloth. The peasants are acquainted with no other linen for cloths, sacks, shirts, &c. Every one prepares his own, none being made for sale.

The genet, genista juncea, has likewise the advantage of affording a green food to cattle during the winter; at the same time that it supports the earth by its roots, and prevents its being carried down into the valleys. The bark of the mulberry tree may be treated in the same manner. Olive de Serres has described a good process for this purpose.

It is the skeleton formed by the vegetable fibre only, and deprived of all foreign matter, which is used to make cloth; it is the most incorruptible principle of vegetation, and when this fibre, being converted into cloth, can no longer be used as such, it is subjected to extreme division, to convert it into paper. The operations for this purpose are the following:—The rags are cleaned, and laid in water to rot; after which they are torn by hooked

pestles moved by water : the second pestles under which they are made to pass, are not armed with hooks like the first, but merely with round nails : the third are of wood only. By this means the rags are converted into a paste, which is attenuated still more by boiling. This paste is received in wire moulds, dried, and forms blotting paper. Writing paper is dipped in size, and sometimes glazed.

CHAPTER VI.

Concerning the Action of Air, of Heat, and of Water upon Vegetables.

WHEN the various juices of vegetables are diffus-ed in water, and the action of this fluid is favour-ed by the combined action of air and heat, a decompo-sition of these juices ensues. The oxigenous gas may be considered as the first agent of fermentation: it is afford-ed either by the atmosphere, or by the water which is de-composed.

It was from an observation of these facts that Becher thought himself authorized to consider fermentation as a kind of combustion :—Nam combustio, seu calcinatio per fortem ignem, licet putrefactionis species, eidemque ana-loga sit—fermentatio ergo definitur, quod sit corporis den-sioris rarefactio, particularumque aerearum interpositio, ex quo concluditur debere in aëre fieri, nec nimium frigido nec nimium calido, ne partes raribiles expellantur, in aper-to tamen vase, vel tantum vacuo ut partes rarefieri queant; nam stricta closura, et vasis impletio, fermentationem tota-liter impedit."—Becher, Phys. Subst. s. i. 15, v. cap. 11, p. 313.

The conditions necessary for the establishment of fer-mentation are—1. The contact of pure air. 2. A certain degree of heat. 3. A quantity of water more or

less considerable, which produces a difference in the effects.

The phenomena which essentially accompany fermentation are—1. The production of heat.   2. The absorption of oxigene.

Fermentation may be assisted—1. By increasing the mass of fermentable matter.   2. By using a proper leaven.

1. By increasing the fermentable mass, the principles on which the air must act are multiplied; consequently the action of this element is facilitated; more heat is therefore produced by the fixation of a greater quantity of air; and consequently the fermentation is promoted by the two causes which most eminently maintain it, heat and air.

2. Two kinds of leaven may be distinguished.   1. Bodies eminently putrescible, the addition of which hastens the fermentation.   Those which already abound with oxigene, and which consequently afford a greater quantity of this principle of fermentation.   This effect is produced by the inhabitants of the banks of the Rhyn, by throwing fresh meat into the vintage, to hasten the spirituous fermentation (Linné Amœnit. Acad. Dissert. de Genesi Calculi) : and so likewise the Chinese throw excrements into a kind of beer, made of a decoction of barley and oats. And on this account it is that the acids, the neutral salts, chalk, rancid oils, and the metallic calces, &c. hasten fermentation.

The products of fermentation have caused different species to be distinguished : but this variety of effects depends on the variety of principles in the vegetables. When the saccharine principle predominates, the result of the fermentation is a spirituous liquor; when, on the contrary, the mucilage is most abundant, the product is acid ; if the gluten be one of the principles of the vegetable, there will be a production of ammoniac in the fermentation : so that the same fermentable mass may undergo different alterations, which always depend on the nature and respective properties of the constituent principles, the susceptibility of change, &c.   Thus a saccharine liquid, after having undergone the spirituous fermentation, may be subjected to the acid fermentation, by the decomposition.

of the mucilage which had resisted the first fermentation : but in all cases the concourse of air, water, and heat, is necessary to develop fermentation. We shall therefore confine ourselves to the examination of these three agents: —1. On the juices extracted from vegetables, and diffused in water, which constitutes the spirituous and acid fermentations ; 2. On the vegetable itself, which will lead us to the formation of vegetable mould, ochres, &c.

ARTICLE I.

Concerning the Spirituous Fermentation and its Products.

That fermentation is distinguished by the name of Spirituous, which affords ardent spirit, or alcohol, as its product or result.

It may be considered as a fundamental principle, that no substances are capable of this fermentation but saccharine bodies. Pure sugar mixed with water forms taffia, or rum, by fermentation ; and we find this principle in the analysis of all the bodies which are susceptible of it.

In order to develop this fermentation, there is required, 1. The access of air. 2. A degree of heat between ten and fifteen of Reaumur. 3. The division and expression of the juice contained in the fruits, or in the plant. 4. A mass or volume somewhat considerable.

We will make the application of these principles to the fermentation of grapes. When these are ripe, and the saccharine principle is developed, they are then pressed, and the juice which flows out is received in vessels of a proper capacity, in which the fermentation appears, and proceeds in the following manner :—At the end of several days, and frequently after a few hours, according to the heat of the atmosphere, the nature of the grapes, the quantity of the liquid, and the temperature of the place in which the operation is performed, a movement is produced in the liquor, which continually increases ; the volume of the fluid increases ; it becomes turbid and oily ; carbonic acid is disengaged, which fills all the unoccupied

part of the vessel, and the temperature rises to the 18th degree. At the end of several days these tumultuous motions subside, the mass falls, the liquor becomes clearer, and is found to be less saccharine, more odorant, and of a red colour, from the reaction of the ardent spirit upon the colouring matter of the pellicle of the grape.*

The causes of an imperfect fermentation are the following: 1. If the heat be too little, the fermentation languishes, the saccharine and oily matters are not sufficiently elaborated, and the wine is unctuous and sweet.

2. If the saccharine body be not sufficiently abundant, as happens in rainy seasons, the wine is weak, and the mucilage which predominates causes it to become sour by its decomposition.

3. If the juice be too watery, concentrated and boiling must is added.

4. If the saccharine principle be not sufficiently abundant, the defect may be remedied by the addition of sugar. Macquer has proved that excellent wine may be made of verjuice and sugar; and Mr. De Bullion has made wine at Bellejames with the verjuice of his vine rows and moist sugar.

There have been many disputes to determine whether grapes should be pressed with the stalks or without. It seems to me that this depends on the nature of the fruit. When they are highly charged with saccharine and mucilaginous matter, the stalk corrects the insipidity of the wine by its bitter principle : but when, on the contrary, the juice is not too sweet, the stalk renders it drier, and very rough.

The wine is usually taken out of the fermenting vessels at the period when all the phenomena of fermentation have subsided. When the mass is settled, the colour of the liquor is well developed, when it has become clear, and its heat has disappeared ; it is put into casks, where, by a second insensible fermentation, the wine is clarified, its

* Richardson, in his Treatise on Brewing, insists much on the difference between the specific gravity of the fluid before and after fermentation, which he considers as proportional to the strength or inebriating quality of the fluid. Fermented liquors have a less specific gravity than they possessed before the fermentation. This circumstance well deserves the attention of the manufacturer. T.

principles combine more perfectly together, and its taste and smell become more and more developed.

If this fermentation be stopped or suffocated, the gaseous principles are retained, and the wine is brisker, and more of the nature of must. Becher had very proper ideas of the effects of these two fermentations.

Distinguitur autem inter fermentationem apertam et clausam : in aperta potus fermentatus sanior est, sed debilior ; in clausa non ita sanus, sed fortior : causa est quod evaporantia rarefacta corpuscula imprimis magna adhuc silvestrium spirituum copia, de quibus antea egimus, retineatur et in ipsum potum se precipitet, unde valde cum fortem reddit. Becher, Phys. Subt. lib. 1, v, V. cap. 11, p. 313.

It appears, from the interesting experiments of the Marquis de Bullion, that the vinous fermentation does not take place unless tartar be present.

By evaporating the must of grapes, a salt is obtained, which has the appearance of tartar, and forms salt of Seignette with the alkali of soda. A large quantity of sugar is also obtained. For this purpose the tartar is first to be extracted ; after which, the must having evaporated to the consistence of a thick syrup, is to be left for six months in a cellar. At the expiration of this time, the sugar is found in a confused state of crystallization ; and this being washed with spirit of wine, to carry off the colouring part, becomes very fine and pure.

Wine deprived of its tartar ferments no more, and the fermentation is in proportion to the abundance of the tartar. Cream of tartar produces the same effect.

It appears that these salts act only as leavens, to facilitate the decomposition of the saccharine principle.

The juice of grapes is not the only vegetable fluid susceptible of the spirituous fermentation.

Apples contain a juice which easily ferments, and produces cyder. Wild apples are usually employed for this purpose. These are bruised, and the juice pressed out, which ferments, and exhibits the same phenomena as the juice of grapes.

In order to have cyder fine, it is to be decanted off the lees as soon as the tumultuous fermentation has subsided, and it begins to be clear. Sometimes, in order to render

it milder, a certain quantity of the juice of apples recent-
ly expressed is added, which produces a second ferment-
ation in the cyder less strong than the first. The cyder
which is left to stand on the lees acquires strength by that
means. Cyder affords the same products as wine; but
the brandy obtained from it has a disagreeable flavour, be-
cause the mucilage, which is very abundant in the cyder,
is altered by the action of the heat of distillation. But if
it be cautiously distilled, it affords excellent brandy, ac-
cording to the experiments of M. Darcet.

The juice of the harshest kind of pears affords, by fer-
mentation, a kind of cyder called Perry.

Cherries likewise afford a tolerably good wine : and a
kind of brandy is obtained from them, which the Ger-
mans call Kirchenwasser.

In Canada the fermentation of the saccharine juice of
the maple affords a very good liquor; and the Americans,
by fermenting the impure syrups of sugar with two
parts of water, form a liquor which affords the spirit
called Taffia, or Rum by the English.*

A drink called Beer, is likewise prepared with certain
grain; such as wheat, oats, and barley; but more especi-
ally with the latter. 1. The grain is made to sprout or ve-
getate, by steeping it in water, and placing it in a heap.
By this means the glutinous principle is destroyed. 2. It
is torrified or stoved, to stop the progress of the fermen-
tation, and fit it for the mill. 3. It is sifted, to separate

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* Peaches, plums, papaws, blackberries, persimmons, potatoes,
turnips, parsnips, carrots, pumpkins, and the stalks of young Indian
corn, &c. all undergo the spirituous fermentation.

Grain of every description affords spirits of different qualities, and
in different quantities according to weight.

Wheat weighing 60 lbs. per bushel, affords from,

			8	to	12	quarts.
Rye	60		10		14	
Indian corn	60		10		14	
Buckwheat			6		8	
Oats	32		5		7	
Barley	45		7		9	
Speltz	60		9		13	
Rice	70		15		6*	

* The American distiller by Michael Krafft, p. 94.

the sprouts or radicles. 4. It is ground into a very coarse flour, named Malt. 5. The malt is infused in hot water, in the mash-tub. This dissolves the sugar and the mucilage, and is called the first wort. It is then drawn off, heated, and again poured on the malt, which forms the second wort.* 6. This infusion, or wort, is boiled with a certain quantity of hops, which communicate an extractive resinous principle to it. 7. An acid leaven, or ferment, is added, and it is poured into a cooler, where it undergoes the spirituous fermentation. When the fermentation has subsided, it is stirred and put into casks, where it continues to ferment, and throws off a frothy scum by the bung, which becomes sour, and serves as a ferment for future brewings, under the name of Yeast.

The product of all the substances is a liquor more or less coloured, capable of affording ardent spirit, by distillation, of an aromatic and resinous smell, a penetrating hot taste, which stimulates the action of the fibres.

Wine is an excellent drink, and is also used as the vehicle of certain medicines. Such are—1. The emetic wine, which is prepared by digesting two pounds of good white wine on four ounces of the crocus metallorum : 2. Chalybeated wine, made by digesting one ounce of steel filings in two pounds of white wine : 3. The wines in which plants are infused; such as wormwood, sorrel, and the liquid laudanum of Sydenham, which is made by digesting for several days two ounces of sliced opium, one ounce of saffron, one dram of pounded cinnamon and of cloves, in one pound of Spanish wine.

We shall proceed to examine the constituent principles of these spirituous liquors, by taking that of grapes for an example. The moment the wine is in the cask, a kind of analysis takes place, which is announced by the separation of some of its constituent principles; such

* In our breweries this practice is only used for double ales : and the strengths in other cases are regulated by the number of times the same malt is wetted, and the time of infusion. The third mashing affords small beer. T.

as the tartar which is deposited at the sides, and the lees which are precipitated to the bottom : so that there remain only the ardent spirit and the colouring matter diffused in a volume of liquid, which is more or less considerable.

1. The colouring principle is of a resinous nature, and is contained in the pellicle of the grape ; and the fluid is not coloured until the wine is formed ; for until then there is nothing which can dissolve it : and hence it is that white wine may be made of red grapes, when the juice of the grape is expressed, and the husk thrown away.

If wine be evaporated, the colouring principle remains in the residue, and may be extracted by spirit of wine.

Old wines lose their colour, a pellicle being precipitated, which is either deposited on the sides of the bottles, or falls to the bottom. If wine be exposed to the heat of the sun during the summer, the colouring matter is detached in a pellicle, which falls to the bottom; when the vessel is opened, the discolouring is more speedy, and it is effected in two or three days during the summer. The wine thus deprived of its colour is not perceptibly weakened.

2. Wine is usually decomposed by distillation ; and the first product of the operation is known by the name of Brandy.

Brandies have been made since the thirteenth century; and it was in Languedoc where this commerce first originated. Arnauld de Villeneuve appears to have been the author of this discovery. The alembics in which wine was distilled consisted for a long time of a kind of boiler, surmounted with a long cylindric neck, very narrow, and terminating in a hollow hemisphere, in which the vapours were condensed. To this small capital was adapted a narrow tube, to convey the fluid into the serpentine or worm pipe. This distillatory apparatus has been successively improved. The column has been considerably lowered; and the stills generally adopted for the distillation of wines in Languedoc are nearly of the following forms. The body of the still is flat at bottom, and the sides rise perpendicularly to the height of twen-

ty-one inches.   At this height the sides incline inwards,
so as to diminish the opening to twelve inches.   This
opening ends in a neck of several inches long, which re-
ceives the basis of a small covering called the head,
which approaches to the figure of an inverted cone.
From the angle of the upper base of the capital, there
issues a small beak, intended to receive the vapours of
brandy, and transmit them into the worm-pipe to which
it is adapted.   This worm-pipe has five or six turns, and
is placed in a tub, which is kept filled with cold water, to
condense the vapours.

The body of the still is usually surrounded by the
masonry as high as the neck, and the bottom only
is exposed to the immediate action of the fire.   An
ash-hole, which is too small, a fire-place large enough,
and a chimney placed opposite the door of the fire-
place, constitute the furnaces in which these stills are
fixed.

The still is charged with between five and six quintals
of wine; the distillation is made in eight or nine hours;
and from sixty to seventy-five pounds of pit-coal are con-
sumed in each distillation.

Every judicious person must be aware of the imper-
fection of this apparatus.   Its principal faults are the fol-
lowing:

1. The form of the body is such as to contain a column
of wine of considerable height and little breadth, which
being acted on by the fire at its base, is burned at that
part before the upper part is heated.

2. The contraction of the upper part renders the
distillation more difficult and slow.   In fact, this inclined
part being continually struck by the air, condenses
the vapours, which incessantly return into the boil-
er.   It likewise opposes the free passage of the va-
pours, and forms a kind of eolipile, as Mr. Beaumé has
observed; so that the vapours, being compressed at this
narrow neck, react on the wine, and oppose its further
ascent.

3. The capital is not constructed in a more advanta-
geous manner.   The upper part becomes of the same
temperature as the vapours, which cannot therefore be

condensed, and, by their reaction, either suspend or re-
tard the distillation.

4. In addition to this imperfect form of the apparatus,
is joined the most disadvantageous method of administer-
ing the fire.   The ash-hole is every where much con-
tracted ; the fire place is very large, and the door shuts
badly.   In consequence of this, a current of air passes be-
tween the combustible matter and the bottom of the still,
and the flame is driven into the chimney, without being
turned to advantage.   A violent fire is therefore required
to heat the stove only to a moderate degree, in this de-
fective construction.

Several other degrees of perfection have been suc-
cessively obtained in the manufactories of Mr. Joubert :
but I have judged it possible to add still more to what
was known, and the following are the principles I set out
from.

The whole art of distillation is reduced to the two fol-
lowing principles:—1. The vapours ought to be dis-
engaged, and raised in the most economical manner :
2. And their condensation ought to be as speedy as
possible.

To answer the first of these conditions, it is necessary
that the boiler should present the largest possible surface
to the fire, and that the heat should be every where equally
applied.   2. The second condition requires that the ascent
of the vapours should not be impeded, and that they
should strike against cold bodies, which shall rapidly con-
dense them.

The stills which I have constructed upon these princi-
ples are more broad than high ; the bottom is concave, in
order that the fire may be nearly at an equal distance from
all the points of its surface ; the sides are elevated per-
pendicularly in such a manner that the body exhibits the
form of a portion of a cylinder ; and this body is covered
with a vast capital, surrounded by its refrigeratory.   This
capital has a groove, or channel, projecting two inches at
its lower part within : the sides have an inclination of
sixty-five degrees ; because I have ascertained that, at
this degree, a drop of brandy will run along without fall-
ing again into the still.   The beak of the capital is as high
and as wide as the capital itself, and insensibly diminishes

till it comes to the worm-pipe itself. The refrigeratory accompanies the beak, or neck, and has a cock at its further end, which suffers the water to run out, while its place is supplied by other cold water, which incessantly flows in from above.

When the water of the refrigeratory begins to be warm, a cock is then opened, that it may escape in proportion as it is more plentifully supplied from above. By this means the water is kept at an equal temperature, and the vapours which strike against the sides of the head are condensed, at the same time that those which rise suffer no obstacle, as they are subjected to no contraction of space. In this construction, the worm-pipe may be almost dispensed with, because the water in the worm-tub does not become perceptibly heated.

These proceedings are very economical and advantageous; for the quality of the brandy is better, and the quantity is larger.

The distillation of the wine is kept up until the product is no longer inflammable. This brandy is put into casks, when it becomes coloured by the extraction of a resinous principle contained in the wood.

The wine of our climates affords one-fifth or one-fourth of brandy, of the proof strength of commerce.

The distillation of brandy by a more moderate heat affords a more volatile fluid, called Spirit of Wine, or Alcohol. To make common spirit of wine, brandy is taken and distilled on a water bath by distillation*. This spirit of wine may be purified and rectified by subsequent distillations, and taking only the first portions which come over.

* The ardent spirit sold in London by the name of Spirit of Wine, or Lamp Spirit, is made by the rectifiers of malt and melasses spirit in London, by distillation of the residues of their compounded spirits. It is pretty constantly of the specific gravity of 0.845 at the temperature of 60 Fahrenheit; and may, by very careful rectification, be brought very nearly up to 0,820. Dry alkali deprives it of more of its water. On the subject of the strength of spirits, consult Blagden in Phil. Trans. vol. lxxxi. T.

Alcohol is a very inflammable and very volatile sub-
stance.   It appears to be formed by the intimate union of
much hydrogene and carbone, according to the analysis
of Mr. Lavoisier.†   This same chemist obtained eighteen
ounces of water by burning one pound of alcohol.   If
well-dephlegmated alcohol be digested upon calcined pot-
ash, and afterwards distilled, a very sweet alcohol is ob-
tained, and a saponaceous extract, which affords alcohol,
ammoniac, and an empyreumatic oil.   In this experiment,
the formation of volatile alkali appears to arise from the
combination of the hydrogene of the alcohol with the ni-
trogene of the potash.

There are various methods used in the arts to judge of
the degree of concentration of spirit of wine.   Gunpow-
der is put into a spoon, and moistened with spirit of wine,
which is set on fire : if the powder takes fire, the spirit
is considered to be good ; but the contrary, if this effect
does not take place.   But this method is fallacious, be-
cause the effect depends on the proportion in which the
spirit of wine is used ; a small quantity always inflames
the powder ; and a strong dose never produces this effect,
because the water which remains soaks into the powder,
and defends it from the combustion.

The areometer of Mr. Baumé is not to be depended
on, because, in the use of it, no account is kept of the
temperature of the atmosphere, which, by changing the
density of the spirit of wine, is productive of a change in
the result as given by this instrument.   That of Mr. Bo-
ries is more accurate, because the thermometer is adapted
to it ; and is now used in commerce.

Alcohol is the solvent of resins, and of most aromatic
substances ; and consequently it forms the basis of the
art of the varnisher and of the perfumer.

† It is supposed that alcohol also contains oxigene.
When equal parts of sulphuric acid and alcohol are mixed toge-
ther, the acid suffers no change ; but the alcohol is decomposed, be-
ing partly converted into water, and partly into ether.   Now, the al-
cohol could not be converted into water, unless it had contained ox-
igene.
If the vapour of alcohol is transmitted through a red-hot porce-
lain tube, it is decomposed and converted into carbonated hydrogene
gas, carbonic acid, water, and charcoal.—*Am. Ed.*

Spirit of wine combined with oxigene forms a liquor nearly insoluble in water, which is called Ether.

Ether has been formed with most of the known acids.

The most ancient of all is the vitriolic or sulphuric ether. To make this, a certain quantity of alcohol is put into a retort, and an equal weight of concentrated sulphuric acid is gradually added. The mixture is shaken and agitated, to prevent the retort from breaking by the partial effect of the heat which arises. The retort is then placed on a heated sand bath, a receiver is adapted, and the mixture is heated to ebullition. Alcohol first passes over; soon after which, streams of fluid appear in the neck of the retort, and within the receiver, which denote the rising of the ether. Its smell is agreeable. Vapours of sulphureous acid succeed the ether; and the receiver must be taken away the moment they appear. If the distillation be continued, sulphureous ether is obtained, and the oil which is called Etherial Oil, or the sweet oil of wine; and that which remains in the retort is a mixture of undecomposed acid, sulphur, and a matter resembling bitumens.

We see that in this operation the sulphuric acid is decomposed; and that the oxigene, by combining with the hydrogene, and the carbone of the alcohol, has formed three states, which we also find in the distillation of some bitumens—1. A very volatile oil or ether. 2. Etherial oil. 3. Bitumen.

If the sulphuric acid be digested upon ether, it converts the whole gradually into etherial oil.

When the ether is mixed with sulphureous vapours, it must be rectified by a gentle heat; a few drops of alkali being first poured in, to combine with the acid.

Sulphuric ether may be made very economically, by using a leaden still with a head of copper well tinned. In this way I prepare it by the quintal without any difficulty. Mr. Cadet has proposed to pour on the residue of the retort one third part of good alcohol, and to distil it in the usual way.

Ether is very light, very volatile, and of a pleasant smell. It is so easily evaporated, that if a fine rag be steeped in this liquor, then wrapped round the ball of a

thermometer, and the instrument be agitated in the air, the thermometer sinks to the freezing point.*

Ether easily burns, and exhibits a blue flame. It is very sparingly soluble in water.

Ether is an excellent antispasmodic. It mitigates pains of the colic as if by enchantment, as it does likewise external pains. The celebrated Bucquet had accustomed himself so much to this drink, that he took two pints per day: a rare example of the power of habit on the constitution.

The mixture of two ounces of spirit of wine, two ounces of ether, and twelve drops of etherial oil, forms the anodyne liquor of Hoffmann.

Messrs. Navier, Woulfe, Laplanche, Bogue, and others, have described various processes for making nitric ether, which are more or less easily imitated. For my part, I take equal parts of alcohol, and nitric acid of commerce, of the strength of between thirty and thirty-five degrees. I put the whole into a tubulated retort, which I fit to a furnace, and adapt two receivers one succeeding the other. The first receiver is immersed in a vessel of water. The second is surrounded by a wet cloth; and a siphon communicates from its tubulure to a vessel of water in which it is plunged. When the heat has penetrated the mixture, much vapours are disengaged, which are condensed in striæ, on the internal surfaces of the receivers, whose external surface is kept constantly cold. The ether which I obtain is very pure and very abundant.†

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* Mr. Cavallo has described, in the Philosophical Trans. for 1781, a pleasing experiment of freezing water by means of ether. The ether is put into a vial so as not completely to fill it; and in the neck of this vial is fitted, by grinding, a tube whose exterior end is drawn out to a capillary fineness. Whenever the bottle thus stopped is inverted, the ether is urged out of the tube in a fine stream, in consequence of the pressure exerted by the elastic etherial vapour which occupies the superior space of the bottle. This stream is directed on the outside of a small glass tube containing water, which it speedily cools down to the freezing point; at which instant the water becomes suddenly opaque, in consequence of the icy crystallization. If a bended wire be previously immersed in the water, it may afterwards be drawn out, and the ice along with it. T.

† The ingenious author has forgotten to caution the inexperienced chemist against the danger of mixing these two liquors. The nitrous acid must be very gradually added to the spirit of wine, by

When the precaution of distilling it properly is attended to, this ether becomes nearly similar to the vitriolic. Messrs. de Lassone and Cornette have observed that it was more sedative.

The distillation of the muriatic acid with alcohol produces only a mixture of these two liquors, which is called the Dulcified Muriatic Acid.

Before the theory of ethers, and the simple process of combining a surplus of oxigene with the muriatic acid, were known, methods were invented to procure the muriatic ether, but substances were always made use of in which the muriatic acid was oxigenated. In this manner it was that the baron de Bornes proposed the concentrated muriate of zinc, mixed and distilled with alcohol; and that the marquis de Courtanvaux distilled the mixture of a pint of alcohol with two pounds and a half of the fuming muriate of tin.

The theory of the formation of ether has in our time led to simpler processes.

Mr. Pelletier introduces a mixture of eight ounces of manganese, and a pound and a half of the muriate of soda, in a large tubulated retort; twelve ounces of sulphuric acid, and eight ounces of alcohol, are afterwards added. Distillation is then proceeded on; and ten ounces of a very etherial liquor are obtained, from which four ounces of good ether are afforded by distillation and rectification.

The very concentrated muriatic acid, distilled from manganese in the aparatus of Woulfe, affords more ether. It is even sufficient, for this purpose, to pass the oxigenated muriatic acid through good alcohol, to convert it into ether.

This muriatic ether has the greatest analogy with the sulphuric. It differs from it in two characters only—1.

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small portions at a time. It is said, and with reason, to be of great importance, that the nitrous acid be added to the spirit, and not the spirit to the acid: for, in this last case, the mixture will, during the greatest part of the time of the operation of combining the fluids, consist of a large portion of acid, with a smaller portion of spirit; whereas, where the contrary method is adopted, the proportion of spirit will always be greater than that of the acid, until the last quantity of acid is added. T.

It emits, in burning, a smell as penetrating as that of the sulphureous acid. 2. Its taste is styptic, resembling that of alum.

From these experiments it is evident that ether is merely a combination of alcohol with the oxigene of the acids made use of. i have even obtained an etherial liquor by repeated distillations of good alcohol from the red oxide of mercury.

The idea of Macquer, who considered ether as spirit of wine dephlegmated, or deprived of water, had little foundation ; for the distillation of the spirit of wine · from the most concentrated or driest alkali, never affords any thing but spirit of wine more or less dephlegmated.

Concerning Tartar.

Tartar is deposited on the sides of casks during fermentation : it forms a lining more or less thick, which is scraped off. This is called crude tartar, and is sold in Languedoc from ten to fifteen livres the quintal.

All wines do not afford the same quantity of tartar. Newman remarked that the Hungarian wines left only a thin stratum ; that the wines of France afforded more ; and that the Rhenish wines afforded the purest and the greatest quantity.

Tartar is distinguished, from its colour, into red or white · the first is afforded by red wine.

The purest tartar exhibits an imperfectly crystallized appearance : the form is the same as we have assigned to the acidulous tartrite of potash ; and it is this quality which is called grained tartar (tartre grenu) in our refineries at Montpellier.

The taste of tartar is acid and vinous. One ounce of water, at the temperature of ten degrees above 0 of Reaumur, dissolves no more than ten grains : boiling water dissolves more, but it falls down in crystals by cooling.

Tartar is purified from an abundant extractive principle by processes which are executed at Montpellier and at Venice.

The following is the process used at Montpellier :—The tartar is dissolved in water, and suffered to crystal-

lize by cooling. The crystals are then boiled in another vessel, with the addition of five or six pounds of the white argillaceous earth of Murviel to each quintal of the salt. After this boiling with the earth, a very white salt is ob- tained by evaporation, which is known by the name of Cream of Tartar, or acidulous tartrite of potash.

M. Desmaretz has informed us (Journal de Phys. 1771) that the process used at Venice consists—1. In drying the tartar in iron boilers. 2. Pounding it, and dissolving it in hot water, which by cooling affords purer crystals. 3. Re-dissolving these crystals in water, and clarifying the solution by whites of eggs and ashes.

The process of Montpellier is preferable to that of Ve- nice. The addition of the ashes introduces a foreign salt, which alters the purity of the product.

The acidulous tartrite of potash crystallizes in tetrahe- dral prisms cut off slantwise.

This salt is used by the dyers as a mordant : but its greatest consumption is in the north, where it is used at table as a seasoner.

Tartar appears to exist in the must, and consequently in the grape itself. This has been ascertained by the ex- periments of De Rouelle and the marquis de Bullion.

This salt exists in many other vegetables. It is suffi- ciently proved that tamarise and sumach contain it ; and the same is true of the barberry, of balm, carduus bene- dictus, restharrow, water-germander, and sage.

The acidulous tartrite of potash may be decomposed by means of fire, in the way of distillation ; in which case the acid and the alkali are obtained separately. This decomposition may also be effected by the sulphuric acid.

The celebrated Scheele has described a process of greater accuracy for obtaining the acid of cream of tartar.

Two pounds of the crystals are dissolved in water, into which chalk is thrown by degrees, till the liquid is satu- rated. A precipitate is formed, which is a true tartrite of lime, is tasteless, and cracks between the teeth. This tartrite is put into a cucurbit; and nine ounces of sulphu- ric acid, with five ounces of water, are poured on it. Af- ter twelve hours digestion, with occasional stirring, the tartareous acid is set at liberty in the solution, and may be cleared of the sulphate of lime by means of cold water.

This tartareous acid affords crystals by evaporation; which, when exposed to the fire, become black, and leave a spongy coal behind.

Treated in a retort, they afford an acid phlegm, and some oil.

The taste of this acid is very sharp.

It combines with alkalis, with lime, with barytes, alumine, magnesia, &c.

The combination of potash with this acid forms cream of tartar, when the acid is in excess; which is capable of entering into combinations, and forming triple salts. Such is the salt of Seignette, or tartrite of soda, which crystallizes in tetrahedral rhomboidal prisms.

The acidulous tartrite of potash is very sparingly soluble in water. Boiling water dissolves only one twenty-eighth part. The addition of borax has been proposed to facilitate the solution; as likewise sugar, which is less efficacious than borax, but makes a very agreeable and purgative lemonade with this salt.

ARTICLE II.

Concerning the Acid Fermentation.

The mucilaginous principle is more especially the substance on which the acid fermentation depends; and when it has been destroyed, in old and generous wines, they are no longer capable of alteration, without the addition of a gummy matter, as I find from my own experiments. It is not true, therefore, to say that all substances which have passed through the vinous fermentation, are capable of passing to the state of vinegar; since this change depends on the mucilage, which may not in all cases be present.

There are, therefore, three causes necessary to produce the acid fermentation in spirituous liquors.

1. The existence of mucilaginous matter, or mucilage. 2. A degree of heat between eighteen and twenty-five degrees of Reaumur. 3. The presence of oxigenous gas.

The process indicated by Boerhaave for making vinegar, is still the most frequently used. It consists in fix-

ing two casks in a warm room or place. Two false bottoms of basket-work are fixed at a certain distance from the bottom, upon which the refuse of grapes and vine twigs are placed. One of these tuns is filled with wine, and the other only half filled. The fermentation begins in this last; and, when it is in full action, it is checked by filling the cask up with wine out of the other. The fermentation then takes place in the last-mentioned cask, that remained half filled; and this is checked in the same manner by pouring back the same quantity of liquid out of the other: and in this way the process is continued till the vinegar is made, which is usually in about fifteen days.

When the fermentation develops itself, the liquid becomes heated and turbid; a great number of filaments are seen in it; it emits a lively smell; and much air is absorbed, according to the observation of the abbé Rozier.

A large quantity of lees is formed, which subsides when the vinegar becomes clear. This lees is very analogous to the fibrous matter.

Vinegar is purified by distillation. The first portions which pass over are weak; but soon afterwards the acetous acid rises, and is stronger the later it comes over in the distillation. This fluid is called Distilled Vinegar; and is thus cleared of its colouring principle, and the lees, which is always more or less abundant.

Vinegar may likewise be concentrated by exposing it to the frost. The superabundant water freezes, and leaves the acid more condensed.

The presence of spirit of wine, mucilage, and air, are necessary to form vinegar. Scheele has made it by decomposing the nitric acid upon sugar and mucilage. I communicated to the Academy at Paris (vol. 1786) an observation of some curiosity respecting the formation of vinegar. Distilled water, impregnated with vinous gas, affords vinegar: at the end of some months, a deposition is made of a substance in flocks, which is analogous to the fibrous matter of vegetables. When the water contains sulphate of lime, an execrable hepatic odour is developed, a deposition of sulphur is afforded, and all this is owing only to the decomposition of this sulphuric acid.

As in the above experiments I had placed the water above the vinous fluid in fermentation, to impregnate it with the carbonic acid, the alcohol which evaporates with the acid carried the mucilage with it ; and the effects, I observed, are referable to this substance.

The acetous acid is capable of combining with a stronger dose of oxigene; and then forms radical vinegar, or the acetic acid.

To form the acetic acid, the metallic oxides are dissolved in the acetous acid ; the salt which is obtained being then exposed to distillation, affords the oxigenated acid. It has a very lively smell, is caustic, and its action upon bodies is very different from that of the acetous acid.

This acetic acid has the advantage of forming ether with alcohol. For this purpose, equal parts of the acid and alcohol are to be distilled together. The product of the distillation is to be again added to the residue in the retort; and a small quantity of the water of Rabel is likewise to be added. The whole becomes converted into ether.

The combination of the acetous acid with potash forms the acetite of potash.

To make this salt, pure potash is saturated with distilled vinegar, the liquor filtered, and evaporated to dryness in a glass vessel over a very gentle fire. The acetite of potash has a penetrating acid taste; is decomposed by distillation ; and affords an acid phlegm, an empyreumatic oil, ammoniac, and a large quantity of very odorant gas, formed of carbonic acid and hydrogene. The coal contains much fixed alkali in a disengaged state. This salt is very soluble in water, and deliquesces in the air.

The sulphuric acid poured upon it, decomposes it; and the products which come over are sulphuric acid and acetic acid.

The acetous acid likewise combines with soda; and this combination is improperly called Crystallizable Terra Foliata. The acetite of soda crystallizes in striated prisms, and does not attract the humidity of the air. When these salts are distilled, they leave a residue, which forms an excellent and very active pyrophorus.

The acetous acid likewise combines with ammo- niac. The acetite which is produced is called the spirit of Mindererus. This salt cannot be evapo- rated without the loss of a considerable part, on ac- count of its volatility: but, by a long evaporation, it affords needle-formed crystals, of a hot and pene- trating taste, and attracting moisture from the air. Lime, fixed alkalis, mere heat or fire, and the acids, decompose this salt.

The sulphate of potash, sprinkled with the acetic acid, forms the salt of vinegar, or vinegar of the four thieves.

ARTICLE III.

Concerning the Putrid Fermentation.

In order that vegetables may undergo the two fer- mentations we have treated of, it is necessary that the juices should be extracted, and presented in a consider- able volume. A due degree of heat, together with other circumstances artificially brought together, are likewise necessary; for a grape, left on the stalk, pro- duces neither ardent spirit nor vinegar, but rots. It is this new kind of alteration we shall at present proceed to treat of.

This fermentation is the most natural termination of the vegetable. It is indeed the only end to which the natural course of things is directed; since it is by this means that the exhausted surface of the globe is repaired. The two other fermentations are the mere effects of art, and form no part of the great plan of nature.

The life of the greatest part of vegetables lasts but a few months; but the seeds they deposit assure their re- production. There are other more robust vegetables which support the cold of winter, and only cast their leaves at that period. The annual vegetables, and vivacious plants, are altered by the combined action of the causes we have

mentioned; and the result, according to the degree of decomposition, is either manure, vegetable earth, or ochre.

The conditions of the vegetable fermentation are the following;

1. It is necessary that the organization be impregnated with water. Dried vegetables are preserved without putrefying; and, if they be moistened, their subsequent alteration is prodigiously accelerated. In this manner it is that plants heaped together become heated, blacken, and take fire, if not sufficiently dried. Fires of this kind are not rare, and the theory is not difficult to be explained. Wetted ropes, moist hay heaped together, and in a word every vegetable substance, putrefies or rots with greater facility, the more perfectly its texture is impregnated with water.

2. The contact of air is the second necessary cause in the putrefaction of vegetables. It is reported, in the Ephemerides of the Curious in Natural Phenomena, for 1787, that ripe cherries were preserved for forty years, by inclosing them in a vessel well luted, and placed at the bottom of a well.

3. A certain degree of heat is likewise necessary. The heat between five and ten degrees is sufficient to cause decomposition. A greater heat dissipates the humidity, dries the vegetable, and preserves it from putrefaction. Too little heat retards or suspends it.

4. It is likewise necessary, for the due effect of this decomposition, that the vegetables should be heaped together, and their juices abundant. A greater quantity of air is then combined with the vegetable; because the juices and the surfaces are then more considerable; and consequently a greater degree of heat is produced, which accelerates the decomposition.

When vegetables are heaped together, and their texture is softened by the humidity with which they are impregnated, together with their own juices, the phenomena of decomposition are the following; the colour of the vegetable is changed; the green leaves become yellow, the texture becomes lax, and the parts less coherent; the colour of the vegetable itself changes to black or brown: the mass rises, and perceptibly swells up; the heat becomes

more intense, and is perceived on approaching the heap; and the fumes which arise have already a smell, which sometimes is not disagreeable ; at the same time bubbles arise, and break at the surface of the liquid, when the vegetables are reduced to a magma. This gas is a mixture of nitrogene, hydrogene, and carbonic acid. At this epocha, likewise, an ammoniacal gas is emitted, which is formed in these circumstances : and, in proportion as these appearances diminish, the strong, and offensive odour is succeeded by another which is fainter and milder, and the mass becomes dry. The internal part still exhibits the vegetable structure, when the stem is solid, and the fibrous matter has been the predominating principle ; and it then constitutes manure or soil. Hence it arises that the herbaceous plants of a loose texture, and abounding in juices, are not capable of forming manure by their decomposition, but are reduced into a brown mass of little consistence, in which neither fibre nor texture are observed ; and this is what, for the most part, forms vegetable mould.

Vegetable mould usually constitutes the first covering or stratum of our globe ; and in such cases wherein it is discovered at a depth in the earth, there is no doubt but it has been buried by some revolution.

When a vegetable is converted into earth by this tumultuous fermentation, it still retains the remains of the vegetable, mixed and confounded with the other solid earths and metallic products; and by distillation it affords oil, nitrogene gas, and often hydrogene. It may therefore be considered as an intermediate substance between crude and organic bodies, which participates of the inertia of the one, and the activity of the other ; and which in this state is still subject to an insensible fermentation, that changes its nature still more, and deprives it of all its organic contents. These remains of vegetables still contained in vegetable earth, serve as food for other plants that may grow in it. The insensible progress of fermentation, and the suction of vegetables, impoverish the vegetable earth, deprive it of all its organic matter, and there remain only the earths and metallic residue which form the stiff poor soils, and ochres when the ferruginous principle is very abundant.

As this muddy earth is a mixture of all the primitive earths, and some of the metals which are the product of vegetation, as well as the oils, the salts, and other products we meet with in it; we may consider it as the residue of vegetable decomposition, as the great agent and means by which nature repairs the continual losses the mineral kingdom undergoes. In this mixture of all the principles the materials of all compounds exist; and these materials are so much the more disposed to enter into combinations, as they are in a more divided and disengaged state. It is in these earths that we find diamonds, quartz-crystals, spars, gypsum, &c. It is in this matrix that the bog ores, or ochreous ores of iron, are formed; and it appears that nature has reserved the impoverished residue of vegetables for the reproduction or reparation of the earthy and metallic substances of the globe, while the organic remains are made to serve as nourishment for the growth of other succeeding vegetables.

PART THE SIXTH.

CONCERNING ANIMAL SUBSTANCES.

INTRODUCTION.

THE abuse which, at the commencement of this cen-
tury, was made of the application of chemistry to
medicine, occasioned, a short time afterwards, that all the
relations between this science and the art of healing were
mistaken and rejected. It would no doubt have been
more prudent, as well as more useful, to have connected
these mistaken applications : but chemistry was not per-
haps at that time in a sufficiently advanced state, to be ad-
vantageously applied to the phenomena of living bodies;
and, even at this day, we see that, though the physiology
of the human body is enriched with various interesting
facts, there is still much to be done before they will be
sufficiently numerous to exhibit a satisfactory mass of doc-
trine.

The imperfect success of chemistry in that branch of
the science which has the study of man for its object,
arises from the very nature of the subject itself. Some
chemists, by considering the human body as a lifeless and
passive substance, have supposed the humours to under-
go the same changes as they would have been subject to
out of the body; others, from a very superficial know-
ledge of the constitution of these humours, have pretend-
ed to explain all the phenomena of the animal economy.
All have mistaken or overlooked that principle of life,
which incessantly acts upon the solids and fluids; modi-
fies, without ceasing, the impression of external objects ;
impedes the degenerations which depend on the constitu-
tion itself ; and presents to us phenomena which chemis-
try never could have known or predicted by attending to
the invariable laws observed in inanimate bodies.

None of the bodies of the mineral kingdom are go-
verned by an internal force. They are all subjected to
the direct action of foreign substances, without any mo-
dification from any vital principle; and the air, water, and
fire, produce in them the effects which are necessary, con-
stant, and subject to calculation; whence it happens that
we are able to determine, modify, and vary the action of
these various agents at pleasure. It is not the same with
living bodies: they are all indeed subject to the influence
of external bodies: but the effect of these is modified by
the re-action of the vital principle, and is varied according
to the disposition of that principle. The chemist cannot
therefore determine the effects *à priori*, and in a general
way. He must search for his results rather in the living
body itself than in the operations of his laboratory; and
can have no assistance from his analysis but in ascertaining
the nature of their component parts. But their action,
effects, or transpositions, can only be known by a serious
study of the functions of the living body. Chemistry
can perform every thing in the mineral kingdom, because
every thing depends on the laws of the affinities. But, in
the kingdoms of organized beings, this science is subor-
dinate to the laws of the economy of living bodies; and
its results can only be affirmed to be true, when they are
confirmed by observation.

The more the functions of the individual are indepen-
dent of organization, the less is the empire of chemistry
over them, because the effects are modified in a thousand
ways; and it is this which renders the application of che-
mical principles to the phenomena of the human body so
very difficult; for the organization is not only very com-
plicated, but the effects are continually varied by the pow-
erful influence of the mind.

There is not however any function in the animal eco-
nomy, upon which the science of chemistry cannot throw
some light. If we consider them in the healthy state, we
shall perceive that every organ produces some change in
the humours it receives; and though the chemist may in-
deed be ignorant of the manner in which such changes
are produced, it is by his art alone that the difference be-
tween the original fluid, and that which has been elabo-
rated, can be ascertained. Besides which, the functions

of the various organs are exercised upon external objects, and these objects come under the consideration of chemistry. We are at present, for example, acquainted with the nature of the air which serves for respiration, its effects on the lungs, and its influence on the animal economy. We are even now able to determine whether any air be good or bad, and know how to correct that which is vitiated, &c. We likewise possess some accurate ideas of the nutritive principle of certain substances; and chemistry teaches us how to dispose of the respective aliments, and adapt them to the various circumstances. The analysis of waters is sufficiently perfect to admit of our distinguishing the properties of that fluid relative to health, and to select the best for our own use : so that, while the principle of life presides over and governs all the internal operations of the human body by a mechanism which is very imperfectly known to us, we see nevertheless that all the functions receive an impression more or less direct from external objects ; that all the materials used for the support of the machine are supplied from without; that the principle of life which collects and disposes of these materials, after laws unknown to us, is capable neither of choosing nor rejecting them ; and that the functions would be very speedily altered, if chemistry, founded on observation, were not careful to remove the noxious, and select such bodies as are of advantage to the system. Chemistry therefore can do nothing in the arrangement of the materials, but possesses unlimited power in their selection and preparation.

When the organization is deranged, this defect of order can arise only from external or internal csuses. In the first case, the analysis of the air, the water, and the food, will afford accurate notions sufficient to re-establish the functions. In the second, the chemical examination of the humours may afford information sufficient to direct the physician in pointing out the most suitable remedy. Sometimes the humours are decomposed in the body, as *in vitro*. We observe all the phenomena of a degeneration and complete disunion of the principles which compose the blood, in the scurvy, cachexy, malignant fevers, &c. It seems as if, in such cases, the vital principle abandoned the government, and left the solids and fluids to the de-

structive action of external agents : in consequence of
which they become decomposed in the same manner as
they usually do when separated from the body.

When the principle of animality is once extinguished,
the same causes which maintained the functions, and whose
effects were modified by that principle of life, now act
with their whole energy on the body, and decompose it.
Chemistry has discovered methods of extracting from
these dead bodies a variety of substances of use in the
arts and in pharmacy.

Chemistry is therefore applicable to the animal econo-
my in the state of health and in the state of sickness.

The chemical art has marked the imits between vege-
table and animal substances. These last afford ammoniac
by putrefaction, while the fermentation of the former de-
velops ardent spirit. The latter leave a coal which burns
easily ; while the former become converted into a coal al-
most incombustible. Animal matters contain much ni-
trogene, which may be disengaged by means of nitric
acid. The interesting Memoirs of Messrs. Berthollet and
De Fourcroy on animal substances, may be consulted to
great advantage.

CHAPTER I.

Concerning Digestion.

THAT humour which is known by the name of the
Gastric Juice, is separated by glands placed be-
tween the membranes which line the stomach ; and from
these it is emitted into the stomach itself.

In order to obtain the gastric juice in a state of purity,
the animals intended to furnish it are kept fasting for two
days, after which the stomach is extracted. In this man-
ner Spallanzani obtained thirty-seven ounces of this juice
out of the two first stomachs of a sheep. The same na-
turalist caused animals to swallow thin tubes of metal,

pierced with several holes, into which he had put small
sponges, very clean and dry.   He caused crows to swallow
eight at a time, which were vomited up at the end of three
hours and a half.   The juice which he obtained was yellow,
transparent, salt, bitter, and leaving very little sediment,
when the bird was fasting.   The gastric juice may like-
wise be procured by the vomiting which is excited by ir-
ritation during fasting.   M. Scopoli has observed that the
most fluid part only is thrown up by irritation ; and that
the thicker part does not quit the stomach but by the as-
sistance of an emetic.   M. Gosse, who had long accus-
tomed himself to swallow the air, which answered the
purpose of an emetic with him, has availed himself of this
habit to make some experiments with the gastric juice.
He suspends his respiration, receives air into his mouth,
and pushes it towards the pharynx with his tongue.   This
air, rarefied in his stomach, produces a convulsive motion,
which clears it of its contents.   Spallanzani has observed
that eagles spontaneously emit a considerable quantity of
gastric juice, when fasting in the morning.

We are indebted to Reaumur and the abbé Spallanzani
for very interesting experiments respecting the virtue and
effects of the gastric juice in digestion.   They caused ani-
mals to swallow tubes of metal, perforated in various
places, and filled with aliments, to examine their effects.
The philosopher of Pavia used purses of thread, and bags
of linen and of woollen.   He himself swallowed small
purses filled with flesh boiled or raw, with bread masti-
cated, and also in its original state, &c. and likewise small
cylinders of wood, five lines in length and three in dia-
meter, pierced with holes, and covered with cloth.

M. Gosse, availing himself of the facility with which
he was able to vomit by means of the air, has taken all
kinds of food, and examined the changes they had under-
gone, by returning them after intervals more or less re-
mote from the time of deglutition.

From these various experiments it follows—1. That the
gastric juice reduces the aliments into an uniform magma,
even out of the body, and *in vitro ;* and that it acts in the
same manner on the stomach after death : which proves
that its effect is chemical, and almost independent of vi-

tality.   2. That the gastric juice effects the solution of the aliments included in tubes of metal, and consequently defended from any trituration.   3. That though there is no trituration in membranous stomachs, this action powerfully assists the effect of the digestive juices in animals whose stomach is muscular, such as ducks, geese, pigeons, &c.   Some of these animals bred up with sufficient care that they might not swallow stones, have nevertheless broken spheres and tubes of metal, blunted lancets, and rounded pieces of glass, which were introduced into their stomachs.   M. Spallanzani has ascertained that flesh included in spheres sufficiently strong to resist the muscular action, was completely digested.   4. That the gastric juice acts by its solvent power, and not as a ferment ; because the ordinary and natural digestion is attended with no disengagement of air, nor inflation, nor heat, nor in a word with any of the phenomena of fermentation.

M. Scopoli observes very well that nothing positive or certain can be asserted respecting the nature of the gastric juice.   It is sometimes acid and sometimes insipid. M. Brugnatelli has found in the gastric juice of carnivorous birds, and some others, a disengaged acid, a resin, and an animal substance, united with a small quantity of common salt.   The gastric juice of ruminating animals contains ammoniac, an extractive animal substance and common salt.   In our time the phosphoric salts have been found disengaged in the gastric juice.

It appears, from the observations of Messrs. Spallanzani and Gosse, that the nature of the gastric juice varies according to that of the aliments.   This juice is constantly acid when the diet is vegetable.   The abbé Spallanzani affirms, contrary to Messrs. Brugnatelli and Carminati, that birds of prey have never afforded him an acid juice ; and he affirms the same of serpents, frogs, fishes, &c.

In order to shew clearly that there is a great difference between the gastric juices of various animals, it is sufficient to observe that the gastric juice of the kite, the falcon, &c. does not dissolve bread, though it digests flesh meat ; and that the gastric juice of the turkey, the duck, &c. has no action upon flesh, but converts the hardest grain into a pulp.

Messrs. Jurine, Toggia, and Carminati, have made the most successful applications of the gastric juice in the treatment of wounds.

CHAPTER II.

Concerning Milk.

OF all the animal humours, milk is beyond contradiction the least animalized. It appears to partake of the nature of chyle; it preserves the qualities and character of the aliments; and for this reason we are induced to place it at the head of the humours of animal bodies.

Milk is separated in organs called breasts or udders; and though the class of animals with breasts exhibits the greatest analogy in the internal construction of these organs, yet the milk varies in the several species. In the human species it is more saccharine; in the cow, milder, or softer: the milk of the goat, and of the ass, are slightly astringent; and it is for this reason that they are ordered to be taken in disorders which have weakened and exhausted the human frame.*

* It seems most probable that the pre-eminence still given to the milk of the ass, arises from no better reason than the loud and sonorous voice of the animal, which, by a kind of reasoning very common among the ancient physicians, has led to a conclusion that the milk of such a creature must be good for the lungs. The root satyrion, the milk of the goat, and many other substances, formerly stood high in medical estimation, for reasons equally obvious and equally superficial. It must not however be denied but that, when the possessor of an exhausted constitution becomes so far obedient to advice as regularly to take asses' milk, and attend to other circumstances of regimen, he may find himself benefited; and the asses' milk, merely as milk, substituted instead of some less friendly beverage or food, may be entitled to a share in the general effect. T.

Milk is the first food of young animals. Their weak and feeble stomachs are incapable of digesting and assimilating aliments afforded by the earth; and nature has accordingly provided them a food more animalized, and consequently more analogous to their structure, until their increased strength permits them to use a coarser food.

Hunter has observed that all the animals which disgorge to feed their young, have glands in the stomach, which are formed during the incubation, and afterwards gradually obliterated.

Milk is in general of an opaque white colour, and saccharine taste.

By attending to the various alterations it undergoes when left to itself, or when decomposed by chemical agents, we may arrive at a perfect knowledge of its nature.

Milk exposed to the air is decomposed in a longer or shorter time, according to the degree of heat of the atmosphere. But if the temperature of the atmosphere be hot, and the milk in large quantity, it may pass to the spirituous fermentation. Marco Polo, the Venetian, who wrote in the thirteenth century, affirms that the Tartars drink mare's milk, so well prepared that it might be taken for white wine. Claude Strahelenberg reports that the Tartars extract a vinous spirit from milk, which they call Arki (Description de l'Empire de Russie). John George Gmelin, in his Voyage to Siberia, affirms that the milk is suffered to become sour, and is afterwards distilled.

M. Nicolas Oseretskowsky of St. Petersburgh, has proved—1. That milk deprived of its cream cannot produce ardent spirit, either with a ferment or without. 2. That milk agitated in a close vessel affords ardent spirit, 3. That fermented milk loses its spirituous principle by heat, and passes to the state of vinegar.—Journal de Phys. 1779.

Milk becomes sour in the summer, and in three or four days the acid has required its strength. If the whey be then filtered, and evaporated to half, cheese is deposited. If it be again filtered and a small quantity of the tartareous acid be added, a quantity of small crystals of tartar are seen to be formed in the course of an hour afterwards, which according to Scheele can (not) arise only from the small quantity of muriate potash (in

milk, but from an essential salt*) which milk always contain.

To separate the various principles contained in sour whey, the following process may be used, which was pointed out by the celebrated Scheele.

Evaporate the sour milk to one eighth. All the acid separates, and remains on the filter. Pour lime water on the residue; an earth is precipitated, and the lime combines with the acid. The lime may be displaced by the oxalic acid, which forms with it an insoluble oxalite, which falls down, and the acid of milk remains disengaged. The fluid is then to be evaporated to the consistence of honey, and upon this very pure alcohol is to be poured. The sugar of milk, and all the other principles, are insoluble, except the acid. The mass being then filtered, the acid of milk may be separated from its solvent by distillation. This is the acid known by the name of Lactic Acid. It possesses the following characters.

1. When saturated with potash, it affords a deliquescent salt, soluble in alcohol.

2. With soda, a salt not crystallizable, and soluble in alcohol.

3. With ammoniac, a deliquescent salt, which suffers most of its alkali to escape before the heat has destroyed the acid.

4. Barytes, lime, and alumine, form with it salts which are deliquescent.

5. Magnesia affords small crystals, which are resolved into a liquor.

6. Bismuth, cobalt, antimony, tin, mercury, silver, and gold, are not attacked by it either hot or cold.

7. It dissolves iron and zinc, and produces hydrogenous gas. The solution of iron is brown, and does not afford crystals : that of zinc crystallizes.

8. With copper it assumes a blue colour, which changes to green, and afterwards to an obscure brown, without crystallizing.

* The words in the parentheses are added, to render the text conformable to Scheele's Essay. T.

9. When kept in digestion upon lead for several days, it dissolves it. The solution does not afford crystals. A light sediment of a white colour is formed, which Scheele considers as a sulphate of lead.

Whey not sour contains a saline substance, known by the name of Sugar of Milk. Messrs. Valgamoz and Lichtenstein have described the process used to obtain this saline substance. The milk is deprived of its cream in the usual manner, and of its curd by rennet. It is then concentrated by evaporation till it has acquired the consistence of honey, after which it is put into moulds, and dried in the sun. This is called Sugar of Milk in cakes (sucre de lait en tablettes). These cakes are dissolved in water, clarified with white of egg, evaporated to the consistence of syrup, and set to crystallize in a cool place. It affords white crystals in rhomboidal parallelopipedons.

Sugar of milk has a slightly saccharine taste, insipid, and as it were earthy. It is soluble in three or four pints* of hot water. Mr. Rouelle obtained from twenty-four to thirty grains of ashes from one pound of this salt burned. Three-fourths consisted of muriate of potash, and the rest was carbonate of potash.

Sugar of milk exhibits the same appearance as sugar, either by distillation, or on the fire. This salt,† treated with the nitric acid, afforded me three gross of oxalic acid in the month of July, 1787 *(Mémoire présenté à la Société Royale des Sciences de Montpellier)*. Scheele observed the same fact nearly at the same time. I obtained it in beautiful crystals ; Scheele, in the form of a white powder.‡

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* By an oversight for *parts*.

† The quantity of salt used is not put down. Scheele obtained five drachms of acid of sugar in long crystals, by distilling nitrous acid from twelve ounces of sugar of milk and seven drachms and a half of the peculiar *acid of sugar of milk* in a white powder. The memoir of Scheele is dated 1780. T.

‡ I do not see by what oversight it is that our ingenious author seems to confuse the two salts together, which are afforded by treating the sugar of milk with nitrous acid. One, as observed in the preceding note, is the oxalic or saccharine acid, and the other

If six spoonfuls of good alcohol be mixed with three pints of milk, and the mixture be exposed to heat in close vessels, with the attention to give, from time to time, a slight vent to the gas of the fermentation; the milk is found, in the course of a month, to be changed into good acetous acid, according to Scheele.

If a bottle be filled with fresh milk, and inverted beneath the surface of milk in an open vessel, and this be subjected to a degree of heat a little exceeding that of summer, at the end of twenty-four hours the milk is found to be coagulated; the gas which is developed displaces the milk : a proof according to Scheele, that the vinous fermentation has taken place.

To decompose milk, and separate its various constituent parts, rennet, or the milk turned sour in the stomach of calves, is commonly made use of. For this purpose the milk is warmed, and twelve or fifteen grains of rennet is added to each pint. Gallium, the flowers of thistle or artichokes, and the internal membrane of the stomach of birds dried, and reduced to powder, &c. are among the substances which may be used to turn milk. The whey obtained in this manner is turbid ; but may be cla-

the acid of sugar of milk. The properties of this last (Scheele's Essays, London, 1786) are the following :

1. It is combustible like oil in a red hot crucible, without leaving any mark of ashes behind. 2. Sixty parts of boiling water, or eighty of cold water, are required to dissolve it. 3. Its taste is sourish, it reddens tincture of litmus, and effervesces with chalk. 4. By destructive distillation it melts, grows black, froths very much ; a brown salt, smelling like a mixture of flowers of benzoin and acid of amber, sublimes; a brown liquid without any appearance of oil, comes over into the receiver, and is found to contain some of the same kind of salt as was sublimed. The sublimed salt is acid, easily soluble in ardent spirit, but more difficultly in water, and burns in the fire with a flame. 5. With all the soluble earths it forms salts insoluble in water. 6. With vegetable alkali it forms a perfectly neutral crystallizable salt, soluble in eight times its weight of boiling water, and separable for the most part by cooling. 7. With mineral alkali it forms a salt which requires only five parts of boiling water for its solution. 8. With volatile alkali it forms a salt which, after being gently dried, has a sourish taste. 9. It does not perceptibly act on the metals ; but forms, with their calces, salts of very difficult solubility, which therefore fall down. T.

rified by boiling it with white of egg, and subsequent fil-
tration.

On the mountain of Larzac I have seen the dairy wo-
man plunge her arms up to the elbows in the milk,
and change their place from time to time. This was
done with a view to hasten the separation of the prin-
ciples; and it is probable that the heat, and perhaps cer-
tain emanations from the arm itself, might favour that
effect.

The solid mass which separates from whey, contains
two other substances very interesting to be known; name-
ly, cheese and butter.

If any vegetable or mineral acid be put into milk, a coa-
gulation follows, as is well known. The only difference
is, that the mineral acid affords less cheese or curd than
the vegetable; and the various substances used to coagu-
late milk, may perhaps act merely by virtue of the acid
they contain. Olaus Borrichius obtained no acid from
curdled milk at a degree of heat incapable of decomposing
it. The coagulum which is afforded in all these cases,
contains a substance of the nature of gluten, which forms
the cheese; and another substance of the nature of oils,
which forms the butter. When cheese is prepared for
the table, the butter is not separated, because it renders it
milder and more agreeable.

The caustic alkalis dissolve cheese by the assistance
of heat. But it is not held in solution by an alkali in
milk.

If one part of cheese newly separated, and not dried,
be mixed with eight parts of water slightly acidulated
by a mineral acid, and the mixture be boiled, the cheese
will be dissolved, though it would not have been sensibly
acted by on by a vegetable acid. This is the cause
why the vegetable acids separate a much greater quanti-
ty of curd from the same quantity of milk than the mi-
neral acids do.

The cause why salts, gums, sugar, &c. coagulate milk,
may be deduced from the greater affinity of the water with
these bodies than with the cheese.

The earth of cheese is a phosphate of lime, according
to Scheele.

No substance has a stronger resemblance to cheese than the white of egg boiled. White of egg is dissolved in diluted acid, and also in caustic alkali, and in lime-water, and is precipitated from them by acids.

Scheele thinks that the coagulation of white of egg, lymph, and cheese, is owing to the combination of caloric; and he proves his opinion as follows:—Mix one part of white of egg with four parts of water; pour in a small quantity of pure alkali; add as much muriatic acid as is necessary to saturate it, and the white of egg will coagulate. In this experiment there is a change of principles. The heat of the alkali combines with the white of egg, and the alkali with the muriatic acid.*

Ammoniac dissolves cheese more effectually than fixed alkalis. If a few drops be poured into coagulated milk, it quickly causes the coagulum to disappear.

Concentrated acids likewise dissolve it. Nitric acid disengages nitrogene.

The curd dried, and placed in a proper situation to undergo a commencement of the putrid fermentation, acquires consistence, taste and colour. In this state it is used at table by the name of Cheese.

At Roquefort, where I have attended the manipulations of the excellent cheese which is made there, care is taken to press the curd well, in order to expel the whey, and to dry it as accurately as possible. After this it is taken into caves, where the temperature is two or three degrees above 0. The fermentation is developed by a small quantity of salt. The putrefaction is suspended by scraping the surface from time to time; and the fermentation thus governed by art, and kept under by the coolness of the caves, produces a slow effect upon all the cheese, and successively develops the red and blue colours, of which I

* The reasoning of Scheele is more fully this:—Heat coagulates white of egg, without diminishing its weight: whence he concludes coagulated white of egg to be a combination of heat with white of egg. Acids expel heat from caustic alkalis when they combine with them, but not from mild alkalis. A very dilute alkali is used in this experiment, that the temperature may not be raised, and nevertheless the effect takes place; but it does not when a mild alkali is used. Whence he concludes that the heat of the caustic alkali, instead of being employed to raise the temperature, has entered into combination with the white of egg, and coagulated it. T.

have given the etiology in a Memoir on the Fabrication of Cheese at Roquefort, presented to the Royal Society of Agriculture, and printed in the fourth volume of the *Annales Chimiques.**

Butter is the third principle contained in milk. It is separated from the scum and the caseous matter by rapid agitation. The substance called cream is a mixture of cheese and butter which floats on the top of the milk. Violent agitation converts this into froth ; in which state it is called *whipped cream.*

Butter has a soft consistence, is of a yellow golden colour more or less deep, of a mild agreeable flavour, melts easily, and becomes solid again by mere cooling.

Butter is easily changed, and becomes rancid like oils. The acid which is developed may be carried off by water, or by spirit of wine, which dissolve it. Fixed alkali dissolves butter, and forms a soap little known.

Distillation affords a coloured concrete oil from butter, and a strong pungent acid. This oil, by repeated distillation, becomes altered, and resembles volatile oils.

Milk is therefore a mixture of oil, lymph, serum, and salt. This mixture is weakly united, and the union between the principles is easily destroyed. Milk is said to be *turned* when the disunion of its principles is effected by mere repose ; but when this separation is made by reagents, it is said to be *curdled*† or coagulated.

* It is in the fourth volume of the *Annale de Chimie* that the author has inserted an extract from his excellent Memoir on this subject. T.

† *lait tourné* and *lait caillé.* This distinction scarcely obtains in the English language. T.

CHAPTER III.

Concerning the Blood.

BLOOD is that red humour which circulates in the human body by means of the arteries and veins, and supports life by supplying all the organs with the peculiar juices they demand. It is this humour which receives the product of digestion from the stomach, which it elaborates and animalizes. This humour is with reason considered as the focus of life. The difference of temperaments with regard to the passions, has been attributed to it by all the philosophers who have treated this subject. It is in vain that physicians have changed their system; for the opinions of the people have been less versatile, and they have continued to attribute all the shades of temperament to the modifications of the blood. It is likewise to the alterations of this humour that physicians have for a long time ascribed the cause of almost every malady. It is more especially entitled to the attention of the chemist.

The blood varies in the same individual, not only with regard to the state of health, but likewise at the same instant. The blood which circulates through the veins has not the same intensity of colour, nor the same consistence, as that of the arteries; that which flows through the organs of the breast differs from that which passes languidly through the viscera of the lower belly.

The blood differs also—1. According to the age. In infancy it is paler and less consistent. 2. According to the temperament. Sanguine persons have the blood of a vermilion red; in the phlegmatic it is paler; and in the choleric it is more yellow.

The temperature of the blood is not the same in the several species of animals. Some have the blood hotter, and some colder, than the medium in which they live. Animals with lungs have the blood redder and hotter than those which are without that organ; and the colour and heat are in proportion to the extent and perfection of the lungs, as M. Buffon and Broussonet have observed.

The blood putrefies by a gentle heat. If it be distilled on the water-bath, it affords phlegm of a faint smell, which easily putrefies. Blood dried by a proper heat, effervesces with acids; if exposed to the air, it attracts humidity; and at the end of several months a saline efflorescence is formed, which Rouelle has ascertained to be soda. If the distillation of blood be carried farther, the product is acid, oil, carbonate of ammoniac, &c. A spongy coal remains in the retort, of very difficult incineration, in which are found sea salt, carbonate of soda, iron, and phosphate of lime.

Alcohol and the acids coagulate the blood; alkalis render it more fluid.

But if the blood received in a shallow bason be observed, the following alterations are seen:—It first becomes divided into two very distinct substances, the one liquid, slightly greenish, and called lymph, or serum; and the other reddish and solid, called the fibrous part of the blood. It is this separation of the blood which has caused the existence of polypi in the larger vessels to be credited, because concretions have been found in those vessels after death. We will separately examine these two substances.

Serum has a yellow colour, inclining to green. Its taste is slightly saline. It contains a disengaged alkali, turns syrup of violets green, and hardens in a moderate heat, which is the character of the lymph. Serum distilled on a water-bath affords an insipid phlegm, neither acid nor alkaline, but very readily putrefying. When this phlegm has passed over, the residue is transparent like horn, no longer soluble in water, and affording by distillation an alkaline phlegm, carbonate of ammoniac, and a fetid blackish oil more or less thick; the remaining coal in the retort is very voluminous, and very difficult to incinerate; the ashes afford muriate of soda and phosphate of lime.

Serum easily putrefies, and then affords much carbonate of ammoniac.

Serum poured into boiling water coagulates; but it contains a part which is soluble in water, to which it communicates a milky colour, and all the properties of milk, according to Bucquet.

Alkalis render the serum more fluid, but acids coagulate it. By filtering and evaporating the fluid, a neutral salt is obtained, consisting of the acid employed, and soda. It appears therefore that the lymph is kept in the liquid state by the predominating alkali.

The thickened serum affords mephitis by the nitric acid, assisted by a slight heat; if the fire be increased, nitrous gas is disengaged : the residue affords the oxalic acid, and a portion of malic acid.

Serum is coagulated by alcohol; but the coagulum is soluble in water, and in this it differs much from the coagulum formed by acids : this difference depends on the circumstance that the alcohol seizes the water which diluted the serum ; whereas the acid seizes the alkali which dissolved it.

The clot or fibrous part of the blood likewise contains much lymph; but this may be disengaged by washing. The water at the same time carries off the colouring matter, which contains much iron ; and this coagulated part, when well washed, forms a fibrous white substance void of smell; which distilled on the water-bath, affords an insipid phlegm, easily susceptible of putrefaction. The residue becomes very dry, even by a gentle heat ; when suddenly exposed to a considerable heat, it shrinks up like parchment ; but when distilled in a retort it affords an alkaline phlegm, carbonate of ammoniac, oil, &c. The coal, which is less voluminous and lighter than that of lymph, affords the phosphate of lime by incineration.

The fibrous part putrefies with considerable quickness, and affords much ammoniac.

The alkalis do not dissolve it, but acids combine with it. The nitric acid disengages much nitrogene, and afterwards dissolves it with effervescence, and disengagement of nitrous gas. The residue affords oxalic acid, and a small quantity of the malic acid.

This fibrous substance is of the nature of the muscular fibre, which caused Bordeu to call the blood fluid flesh : and long before the time of this celebrated physician, Paul Zacchia asserted that " caro nihil aliud est quam sanguis concretus" (Quest. Legalis, p. 239). This fibrous matter is more animalized than the lymph ; and

it appears to be prepared by the very act of circula-
tion to concur in augmenting the parts of the human
body.

Blood contains much iron. The experiments of Men-
ghini, Bucquet, and Lorry, prove that this metal is ca-
pable of passing into the blood by the first passages,
since patients who are under a course of martial medicine
void it by the way of urine. When the coagulated part
of the blood has been washed, if that part which has re-
tained the colouring matter be burned, and the coal lix-
ivated, the residue of this lixivium is in the state of
saffron of mars, of a fine colour, and usually obedient to
the magnet.

The colour of blood has been attributed to iron ; and
it is very true that the colour appears to be entirely
formed of it, for there exists no vestige of this metal
in the washed and discoloured coagulum : but as, on the
other hand, the blood does not become coloured without
the concourse of air, and as oxigene alone is absorbed in
respiration, it appears that the colour is owing to iron
calcined by the pure air, and reduced to the state of red
oxide.

From this manner of conceiving the phenomenon, we
may perceive why animal substances are so advantageous
in assisting and facilitating the red dye, and why these
substances take colours more easily.

CHAPTER IV.

Concerning Fat.

FAT is a condensed inflammable juice contained in
the cellular membrane : its colour is usually white,
but sometimes yellow; its taste insipid ; and its consist-
ence more or less firm, in the various species of animals.

In cetaceous and other fish, it is nearly fluid; in carni-
vorous animals the fat is more fluid than in frugivorous
animals, according to Mr. De Fourcroy. In the same
animal it is more solid near the kidneys, and under
the skin, than in the vicinity of the moveable viscera;
as the animal grows old, the fat becomes yellow, and more
solid. Consult De Fourcroy. To obtain fat in a state
of purity, it is cut into small pieces; the membranes and
smaller vessels are separated; it is washed, then fused
with a small quantity of water, and kept in fusion until
all the water is evaporated. This last fluid which floats
above it, boils; and when the ebullition ceases, it is a
proof that all the water is dissipated.

Fat has the greatest analogy with oils. Like them it is
not miscible with water : it forms soaps with alkalis; and
burns in the open air, by the contact of an ignited sub-
stance, at a sufficient heat.

Neumann treated the fat of the goose, of the hog, of
the sheep, and of the ox, in a glass retort by a graduated
fire. He obtained phlegm, and empyreumatic and brown-
ish oil, and a brilliant coal. He concludes from his
analysis that there is little difference between fats; and
that that of the ox appears only to contain a little more
earthy matter. This very imperfect analysis throws no
light on the nature of fat; and we are indebted to Messrs.
Segner and Crell for experiments of a much more in-
teresting kind. We shall relate the chief.

1. Beef suet distilled on the water-bath, in a glass re-
tort, affords oil and phlegm; it forms soaps with potash :
the reddish phlegm has an acid taste; effervesces with al-
kali, without reddening the syrup of violets, which assumes
a brown colour by this mixture.

2. The marrow of beef affords the same products,
excepting that a substance first passes over of the
consistence of butter. The phlegm has no smell
when cold. Fixed alkali occasions a weak efferves-
cence.

Mr. Crell has instructed us in the means of obtaining
a peculiar acid from fat, which is at present distinguished
by the name of the Sebacic Acid.

He at first attempted to concentrate this acid by dis-
tilling off the phlegm; but this did not succeed, for the

liquid in the receiver was as acid as that in the retort.
He then saturated all the acid with potash, and obtained
a brownish salt by evaporation, which he fused in a cru-
cible to burn the oil which contaminated it.   This salt,
by solution and evaporation, afforded a foliated salt.   He
poured four ounces of sulphuric acid upon ten ounces of
the salt, and distilled by a very gentle fire.   The sebacic
acid passed over in the form of a greyish vapour; and
half an ounce, very fuming and acrid, was found in the
receiver.   Crell observes that, in order to succeed in this
operation, the salt must be kept a long time in fusion,
without which the acid would be mixed with oil, which
weakens its virtue.

By distillation of fat in a copper alembic, Mr.
Crell obtained the pure acid.   But the fire necessary
for this purpose alters the vessel, causes the tin to
run off, and the acid itself becomes charged with
copper.

It has long been known that the alkalis form a kind
of soap with animal fat.   Mr. Crell, by treating this
soap with a solution of alum, separated the oil, and
obtained the sebate of potash by evaporation :   the
sulphuric acid afterwards distilled from this salt de-
composes it; and by this means the sebacic acid is se-
parated.

Mr. De Morveau melted suet in an iron pot; and
to this he added pulverized quicklime, taking care
to stir it continually at the commencement ; at the
end of the operation, a considerable heat was applied,
taking care to raise the vessels, in order to avoid expo-
sure to the vapours.   When the whole was cold, it was
found that the suet had no longer the same solidity.
This was boiled in a large quantity of water; and the
lixivium, after filtration, afforded a brown acrid salt, which
is the sebate of lime.   This salt is soluble in water, but
would require too much time to purify it by repeated
crystallizations.   This purpose is more easily answered
by exposing it to a degree of heat capable of burning
the oil; after which, a single solution is sufficient to
purify it.   It leaves its oil upon the filter in the state of
coal ; and nothing more is then necessary than to evapo-
rate it.

The solution usually contains a small quantity of quick-lime, which may be precipitated by the carbonic acid. This salt treated in the same manner as the sebate of potash, affords the sebacic acid.

This acid exists ready formed in suet : two pounds afforded somewhat more than seven ounces to Crell.   It exists ready formed in the fat, since earths and alkalis disengage it.

It has the greatest affinity with the muriatic acid as it forms with potash a salt which melts in the fire without being decomposed; it acts powerfully on gold, when mixed with the nitric acid; it precipitates silver from the nitrate of silver; it forms a sublimate with mercury, and the solution of this sublimate is not rendered turbid by the muriate of soda.   But though this acid approaches the muriate in several respects, it differs from it in others, and hitherto seems to be nothing but a modification of that acid.   With soda, it forms crystals in needles, and a crystallized salt with lime.   It decomposes common salt, &c.

Mr. Crell obtained the acid of fat by distillation from the butter of cacao.   Spermaceti likewise affords it.

The properties of this acid are the following :

It reddens blue vegetable colours.

It assumes a yellow colour by fire, and leaves a residue, which announces a partial decomposition.   From this circumstance, Mr. Crell considers it as occupying the middle space between the vegetable acids which are destroyed by fire, and the mineral which receive no alteration.   Its existence in the butter of cacao, and in fats, is favourable to the notion of Crell on this subject.

It attacks the carbonates of lime and alkali with effervescence, and with them forms salts which Bergmann finds to be very similar to the acetites with the same basis.

This acid, as Mr. De Morveau observes, seems to have some action upon glass.   Mr. Crell having digested it several times upon gold, always obtained a precipitate of white earth, which was not lime, but which he presumes to have been carried up in the distillation, and could only arise from the retort itself.

This acid does not perceptibly act on gold : but it at-
tacks the oxide, and forms a crystallizable salt, as it does
likewise with the precipitates of platina.

It unites with mercury and with silver ; yielding the lat-
ter to the muriatic acid, but not the former : it takes both
from the sulphuric acid, lead from the nitric and acetous
acids, and tin from the nitro-muriatic acid.

It attacks neither bismuth, cobalt, nor nickel.

It does not decompose the sulphates of copper, of iron,
or of zinc ; nor the nitrates of arsenic, manganese, zinc, &c.

It reduces the oxide of arsenic by distillation. Crell
formed a sebacic ether.

From this analysis it appears that fat is a kind of oil or
butter rendered concrete by an acid.

Its uses are—1. To keep up the heat of the body, and
defend the viscera from the impression of external cold.
2. To serve as nourishment or support for the animal on
the occasions of want, sickness, &c.

CHAPTER V.

Concerning the Bile.

THE Bile is one of those humours which it is essen-
tial to know, on account of the influence and ef-
fect it has both in the states of health and disorder. We
shall even see that its analysis is sufficiently perfect to af-
ford instruction in an infinity of cases.

This humour is separated in a large viscus of the lower
belly, called the Liver ; it is afterwards deposited in a
bladder, or reservoir, called the Gall Bladder ; from which
it is conveyed into the duodenum, by a particular channel.

The bile is glutinous, or imperfectly fluid, like oil ; of
a very bitter taste ; a green colour, inclining to yellow ;
and froths by agitation like the solution of soap.

If it be distilled on the water-bath, it affords a phlegm,
which is neither acid nor alkaline, but putrefies. This
phlegm, according to the observation of Mr. De Four-

croy, often emits a smell resembling that of musk : bile itself has the same property, according to the general observation of butchers. When the bile has given out all the water it is capable of affording upon the water-bath, the residue is a dry extract, which attracts the humidity of the air, is tenacious, pitchy, and soluble in water. By distillation in a retort, it affords ammoniac, an empyreumatic animal oil, concrete alkali, and inflammable air. The coal is more easily incinerated than that we have last treated of. It contains iron, carbonate of soda, and phosphate of lime.

All the acids decompose bile ; and disengage an oily substance, which rises to the top. The salts afterwards obtained by evaporation, have soda for their basis ; which shews that the bile is a true animal soap. The oil which is combined with soda is analogous to resins, is soluble in spirit of wine, &c.

The metallic solutions decompose bile by double affinity, and produce metallic soaps.

Bile unites with oils, and cleans stuffs in the same manner as soap.

Bile is soluble in alcohol, which separates the albuminous principle. It is this last substance which renders bile coagulable by fire and by acids ; and it is this likewise which hastens its putrefaction.

The constituent principles of bile are, water, a spiritus rector, a lymphatic substance, a resinous oil, and soda. Mr. Cadet has found a salt in it, which he thought similar to sugar of milk ; this salt is probably no other than that which was discovered by Mr. Poulletier.

Bile is therefore a soap, resulting from the combination of soda with a matter of the nature of resins, and a lymphatic substance, which renders it susceptible of putrefaction and coagulation. This substance gives the bile the character of animalization, diminishes its acridity, and favours its mixture with the other humours. The saline part renders the bile more fluid and soluble in water ; and it is more acrid the more this principle abounds.

The resinous part differs from vegetable resins—1. Because these do not form soap with fixed alkalis. 2. Because they are more acrid and more inflammable. 3. Because the animal resin melts at the temperature of 40 de-

grees, and acquires a fluidity similar to that of fat; from which however it differs in not being soluble in alcohol, in which respect it approaches to spermaceti.

The acids which act upon bile in the first passages, decompose it. The greenish yellow colour of the excrements of infants at the breast, arises from a similar decomposition; and it is the resinous part which tinges them. From the action of the bile upon acids, we may deduce the effect of these remedies when the evacuations are putrid, and the degeneration of the bile is septic. The lymph is then coagulated, and the excrements become harder. This shews the reason why the excrements of infants are so frequently clotted.

When the bile remains a long time in the first passages, as for example in chronical disorders, it assumes a black colour, becomes thick, acquires the consistence of an unguent, and forms a lining of several lines in thickness in the intestinal canal, according to the observation of Mr. De Fourcroy. When smeared on paper, and dried, it becomes green; diluted with water, it forms a tincture of a yellow green colour, from which a large quantity of black scales are precipitated: with alcohol it likewise forms a black tincture, and deposites that laminated brilliant salt discovered in biliary calculi by Mr. Poulletier de la Salle. This humour, which forms the atra bilis of the ancients, is nothing but the bile rendered thick; and in this case the effect of acids, and the danger of irritating substances, may be easily accounted for. This thickening of the bile clogs the viscera of the lower belly, and produces obstructions.

Many disorders are referable to the predominant character of the bile. On this subject, the interesting Memoirs of Mr. De Fourcroy may be consulted, in the collection of the Royal Society of Medicine for the years 1782 and 1783.

When the bile becomes thick in the gall bladder, it forms the concretions called biliary calculi. Mr. Poulletier has paid great attention to the analysis of these stones. He has observed that they are soluble in ardent spirit. When the solution is left to itself for a certain time, brilliant and light particles are seen in it, which Mr. Poulletier found only in the human calculi, and which appeared

to him to have the greatest analogy with the salt of ben-
zoin.

Mr. Fourcroy has observed that the discovery of Mr.
De la Salle has been confirmed by the Royal Society of
Medicine, which has received several biliary calculi that
appeared to be formed by a salt analogous to that which
was observed by this chemist. They consist of masses
of transparent crystalline plates, similar to mica or talk.
The Society of Medicine possesses in its collection a gall
bladder entirely filled with this saline concretion.

We may, therefore, as Mr. De Fourcroy observes, ad-
mit of two kinds of calculi : the one are opaque, and are
afforded only by the condensed bile ; the others consist of
the crystals we have described.

Boerhaave observed, long since, that the gall bladder
of oxen, at the end of the winter, was filled with calculi,
but that the fresh pasturage dissipated these concretions.

Soaps have been proposed as solvents for these calculi.
The Academy of Dijon has published the success of a
mixture of essence of turpentine and ether. Fresh ve-
getables, which are such sovereign remedies in destroy-
ing these concretions, owe their virtue perhaps to the cir-
cumstance that they develop an acid in the stomach, as
we have observed in treating of the gastric juice.

The use of the bile, in the animal economy, consists,
no doubt, in dividing those substances which have under-
gone a first digestion in the stomach ; and in giving effi-
cacy and force to the motion of the intestines. When its
flux is interrupted, it abounds in the blood, and the whole
body becomes of a yellow tinge.

The bile or gall is an excellent vulnerary externally ap-
plied : internally taken, it is a good stomachic, and one of
the best deobstruents the art of medicine possesses. This
kind of remedies deserves the preference, as being more
analogous to the constitution ; and bile is a proper medi-
cine when the digestion languishes, or the viscera of the
lower belly are clogged.

Bile, like other soaps, removes spots of oil, or other
greasy matter, from substances to which they are ad-
herent.

CHAPTER VI.

Concerning the Soft and White Parts of Animals.

THESE parts are perhaps less known than those of which we have just treated; but their analysis is not less interesting: we may even affirm that it is more so; because the application of the knowledge we may acquire on this subject, will daily present itself in the commonest purposes of domestic life.

All the parts of animals, whether membranes, tendons, aponeuroses, cartilages, ligaments, or even the skin and horns, contain a mucous substance very soluble in water, but not in alcohol, and known by the name of Jelly. Nothing need be done to obtain it, but to boil these animal substances in water, and concentrate the decoction, until by mere cooling it assumes the form of a solid tremulous mass.

Jellies are very common in our kitchens: and the cooks are perfectly well acquainted with the methods of making them, and of giving them solidity when the temperature of the atmosphere is very hot. The jelly of harts-horn is extracted by a similar operation, and afterwards rendered white with the milk of almonds. This kind of food, duly scented, is served up at our tables by the name of *blanc manger*. Jellies are in general restorative and nourishing: that of harts-horn is astringent and emollient.

Jellies in general have no smell in their natural state, and their taste is insipid. By distillation they afford an insipid and inodorous phlegm, which easily putrefies. A stronger heat causes them to swell up, become black and emit a fetid odour accompanied with white acrid fumes. An alkaline phlegm then passes over, succeeded by an empyreumatic oil, and a little carbonate of ammoniac. A spongy coal remains, which is with difficulty reduced to ashes, and affords by analysis muriate of soda, and phosphate of lime.

Jelly cannot be kept above a day in the summer, or two or three in the winter. When it becomes spoiled, white livid spots are formed on its surface, which speedily

extend to the bottom of the pots. A large quantity of nitrogenous, hydrogenous, and carbonic gas is emitted.

Water dissolves jellies perfectly. Hot water dissolves a large quantity, as they become consistent only by cooling. Acids likewise dissolve them, and alkalis more especially do.

The nitric acid disengages nitrogene gas, according to the fine experiments of M. Berthollet.

When jelly has been extracted without long decoction, and has no lymph mixed with it, it then possesses most of the characters of the vegetable jelly : but it is seldom obtained without a mixture of lymph ; and in this case it essentially differs from the vegetable jellies, in affording nitrogene gas and ammoniac.

If jelly be concentrated to such a degree as to give it the form of a cake, it is deprived of the property of putrefying ; and by this means the dry or portable soups are formed, which may be of the greatest advantage in long voyages. The following is a receipt for preparing these cakes :

Calves feet	4
Leg of beef	12 pounds.
Knuckle of veal	3 pounds.
Leg of mutton	10 pounds.

These are to be boiled in a sufficient quantity of water, and the scum taken off as usual ; after which the soup is to be separated from the meat by straining and pressure. The meat is then to be boiled a second time in other water ; and the two decoctions, being added together, must be left to cool, in order that the fat may be exactly separated. The soup must then be clarified with five or six whites of eggs, and a sufficient quantity of common salt added. The liquor is then strained through flannel, and evaporated on the water-bath to the consistence of a very thick paste ; after which it is spread rather thin upon a smooth stone, then cut into cakes, and lastly dried in a stove until it becomes brittle : these cakes are kept in well closed bottles. The same process may be used to make a portable soup of the flesh of poultry ; and aromatic herbs may be used as a seasoning, if thought proper.

These tablets or cakes may be kept four or five years.
When intended to be used, the quantity of half an ounce
is put into a large glass of boiling water, which is to be
covered, and set upon hot ashes for a quarter of an hour,
or until the whole is entirely dissolved.   It forms an ex-
cellent soup, and requires no addition but a small quan-
tity of salt.

The cakes of hockiac, which are prepared in China,
and are known in France by the name of *colle de peau
d'âne*, are made with animal substances.   They are used
in disorders of the lungs, in the dose from half a dram to
two drams.

The nature of the substances made use of, and the me-
thod of operating, produce some difference in these pro-
ducts.   Old or lean animals afford in general a better glue
than the young and fat.   For a full account of the art of
making glue, consult *L'Art de faire différentes Espéces
de Colle, par M. Duhamel de Monceau, de l'Académie
des Sciences.*

1. To make the strong or English glue, the parings of
leather, the skins of animals, with the ears of oxen, calves,
sheep, &c. are used.   These matters are first digested in
water, to penetrate the texture of the skins ; they are af-
terwards steeped in lime water, taking care to stir and agitate
them from time to time; they are then laid in a heap for some
time, afterwards washed, and the superabundant water
pressed out by a press.   These skins are then digested in
water gradually heated to ebullition.   The liquor is after-
wards poured out, and separated with pressure.   Lastly,
it is thickened by evaporation of the water by heat, and
poured on flat polished stones or into moulds, and left to
dry and harden.

This glue is brittle.   It is softened by heating it with a
small quantity of water for use, and is applied with a
brush.   Carpenters and cabinet-makers use it to fasten
pieces of wood together.

2. The glue of Flanders is merely a diminutive of the
strong glue.   It has not the same consistence, and cannot
be used in glueing wood ; it is thinner and more transpa-
rent than the former.   It is made with a more accurate
choice of materials, and with greater care.   It is used by
designers.   Mouth glue is made of this, to stick paper to-

gether, by fusing it again with the addition of a small quantity of water, and four ounces of sugar-candy to a pound of the glue.

3. The colle de gand is made with the clippings of white gloves, well steeped in water, and boiled : it is likewise made with the clippings of parchment. In order that these two kinds of glue may be fit for use, it is necessary that they be of the consistence of a tremulous jelly when cold.*

4. Fish-glue, or isinglass, is made of the mucilaginous parts of a large fish commonly found in the Russian seas. The skin, the fins, and the nervous parts, are cut into slices, boiled on a slow fire to the consistence of jelly, spread out to the thickness of a sheet of paper, and formed into cakes or long pieces, such as we receive them from Holland. The silk manufacturers, and more especially the ribbon weavers, use it to give a lustre to their goods : it is also used to stiffen gauzes ; and to clarify or fine wine, by mixing a solution of this substance with it. Isinglass enters into the composition of some plasters. It is excellent to correct acrid humours, and terminate obstinate venereal disorders.

Gilder's size is made by boiling eel-skins in water with a small quantity of lime : the water is strained off, and some whites of eggs added. When it is intended to be used, it is heated, applied to the surface intended to be gilded, and when it is dry the gold leaf is laid on.

5. The glue of snails is made by exposing snails to the sun, and receiving in a glass the fluid which flows from them. This liquor is mixed with the juice of milk thistle. It is used to cement glasses together, which are afterwards exposed to the sun to dry.

6. To make the glue of parchment, or parchment size, two or three pounds of the clippings of parchment are put into a pail of water. These are boiled until half the water is evaporated ; after which the whole is strained through a cloth, and left to settle.

* These weaker glues are called Size by our workmen, who apply the name of Glue to the strong glue only. T.

The glue or size used in the paper manufactories, to fortify the paper, and to repair its defects, is made with wheat flour diffused in boiling water, and strained through a sieve. This size must be used the following day, and neither sooner nor later. The paper is afterwards beat with a mallet, sized a second time, put into the press to smooth and unite it, and afterwards extended by hammering.

CHAPTER VII.

Concerning the Muscular or Fleshy Parts.

THE muscles of animals are formed of longitudinal fibres connected together by the cellular membrane, and impregnated with various humours, in which we find partly those we have already examined separately.

The analysis of these substances by distillation afforded us little instruction respecting their nature. The products were, water which easily became putrid, alkaline phlegm, empyrcumatic oil, carbonate of ammoniac, and a coal which afforded by incineration a small quantity of fixed alkali, and febrifuge salt.

The process which succeeds the best for separately obtaining the various substances which compose muscles, is the following, which has been pointed out to us by Mr. De Fourcroy.

1. The muscle is first washed in cold water : by this means the colouring lymph, and a saline substance, are taken up. By slow evaporation of this water, the lymph coagulates, and may be separated by the filter ; and a continuance of the evaporation affords the saline matter.

2. The residue of the first washing is digested in alcohol, which dissolves the extractive matter, and a por-

tion of the salt; the extract is separated by the evaporation of the alcohol.

3. The residue of these first operations, is to be boiled in water, which takes up the jelly, the fat part, and the remaining saline and extractive matters. The fat oil swims on the surface, and may be taken off.

4. After these operations, there remains only a white insipid fibrous substance, insoluble in water; which contracts by heat, like other animal substances; affords ammoniac, and very fetid oil, by distillation. Nitrogene gas is obtained from it by the nitric acid. It possesses all the characters of the fibrous part of the blood, in which fluid it is formed, to be afterwards deposited in the muscles, where it receives the last character appropriated to it.

Mr. Thouvenel, to whom we are indebted for interesting researches on this subject, has found in flesh a mucous extractive substance, soluble in water and in alcohol, possessing a peculiar taste which jelly has not; and when this substance is very much concentrated, it assumes an acrid and bitter taste. Fire develops an aromatic flavour in it. This substance, evaporated to dryness, assumes a bitter, acrid, and saline taste. It swells up upon hot coals, and liquefies; emitting an acid, penetrating smell, resembling that of burned sugar. It attracts the humidity of the air, and forms a saline efflorescence. In a hot atmosphere it becomes sour, and putrefies. All these characters indicate a resemblance between this substance, the saponaceous extracts, and the saccharine matter of vegetables. Mr. Thouvenel, who has likewise analyzed the salt obtained by the decoction and slow evaporation of flesh, obtained it sometimes in the form of down, and sometimes in that of crystals, whose figure he could not describe. This salt appeared to him to be a phosphate of potash in frugivorous quadrupeds, and a muriate of potash in carnivorous reptiles. It is probable, as Mr. De Fourcroy observes, that this salt is a phosphate of soda or of ammoniac, mixed with the phosphate of lime. These salts are indicated, and even with excess of acid, like those of urine, by lime-water and ammoniac, which form white precipitates in the decoction of flesh.

The most abundant part of muscles, and that which constitutes their predominating character, is the fibrous matter. The characters which distinguish this substance are—

1. It is not soluble in water.   2. It affords more nitrogene gas by the nitric acid than other substances do.   3. It afterwards affords the oxalic acid, and the malic acid.   4. It putrefies easily when moistened, and affords much concrete ammoniac by distillation.

The other three substances contained in flesh, namely the lymph, the jelly, and the fat part, are the same substances concerning which we have already treated, under the same denominations.

From these principles we may give the ethiology of the formation of soup, and follow the successive disengagement of all the principles we have spoken of.

The first impression of the fire, when a soup is made, is the disengagement of a considerable scum, which is taken off until it no longer appears.   This scum arises merely from the disengagement of the lymph, which coagulates by the heat.   It assumes, by the impression of the fire, a red colour, which it does not naturally possess.

At the same time the gelatinous part is disengaged, which remains dissolved in the soup, and congeals only by cooling.   It forms on the surface of cold soup a body more or less thick, according to the nature of the substances, and the age of the animals; for young animals afford a larger quantity than such as are old.

As soon as the flesh is penetrated by heat, flat round drops arise, and float at the surface of the fluid, in which they are not afterwards dissolved, but congeal by cooling, and exhibit all the characters of fat.

In proportion as the digestion proceeds, the mucous extractive part separates; the soup becomes coloured, assumes its peculiar odour and taste; and it is more

particularly to this principle that its properties are owing.

The salt which is at the same time dissolved takes off the insipidity of all the before-mentioned principles: and at this period the soup is completely made.

According to the nature of the several principles which are disengaged, and the order in which they appear, it is evident that the management of the fire is not a matter of indifference. If the ebullition be hastened, and a proper time be not allowed for the disengagement of the mucous extractive matter, the three inodorous and insipid principles are obtained; and this is observed in soups made by cooks who are hastened, or have not time allowed to pay a due attention to their work. When on the contrary, the digestion is made over a slow fire, the principles separate one after the other, in order; the skimming is more accurately performed; the aromatic flavour which is disengaged combines more intimately, and the soup is of an excellent flavour. These are the soups of the good women who perform better with a small quantity of meat, than professed cooks with their usual prodigality, and in this case we may say that the form is of more value than the substance.

The heat must not be applied too long; for the great evaporation, by concentrating the principle of smell and taste, at the same time with the salt, renders them acrid and bitter.

CHAPTER VIII.

Concerning Urine.

URINE is an excrementitious humour of the body: and it is one of the fluids of which it is of the greatest importance to possess an accurate knowledge; because the practical physician may derive the greatest

advantage from information of this nature. It is known
to what a degree of extravagance the marvellous pretensi-
ons of this kind have been carried. The delirium has
proceeded to such a height, as even to pretend to ascer-
tain from the urine, not only the nature of the disorder,
and the character of the patient, but likewise the sex and
condition.

The true physician has never given into this excess:
but he has always derived assistance, in his practice, from
the characters exhibited by the urine; and this is the hu-
mour from which he may draw the most satisfactory indi-
cations. It carries out, as we may say, the internal charac-
ter; and a physician who knows how to form a judgment
upon its properties, may deduce the most instructive con-
sequences from it. Monro, in his Treatise of Compara-
tive Anatomy, has described the organs which, in birds,
supply the place of the kidneys: they are placed near the
vertebral column; and communicate, by two ducts, to the
vicinity of the anus. He affirms that the urine of birds is
that whitish substance which almost always accompanies
the excrements.

Chemical analysis ought to enlighten the physician in
his researches concerning the Urine. The nature of the
principles it carries off in certain circumstances, affords
vast information respecting the predominant principle in
the fluids of the human body. Its various states shew
the disposition of the constitution. Persons of a very
irritable habit have the urine of a lighter colour than
others; gouty persons evacuate turbid urine; and it has
been observed that, when the bones become soft, the
urine carries off the phosphate of lime, which constitutes
their basis; instances of which were observed in the per-
sons of Mrs. Supiot, the widow Melin, &c. The vari-
ous states of any disorder are always pointed out by the
state of the urine; and the truly practical physician will
there observe signs of crudity and concoction which will
direct his proceedings.

Urine is likewise an humour interesting to be known
on account of the various uses to which it is applied in
the arts. It was from this substance alone that phospho-
rus was, for a long time, extracted; it is to this fluid that
we owe the development of the blue colour of turnsol.

and the violet of archil; it may be successfully employed
in forming artificial nitre beds; it powerfully contributes
to the formation of sal ammoniac; it may be used to pre-
pare the alkali in the manufacture of Prussian blue; and,
in a word, it may be applied in all the operations wherein
the concurrence of an animal humour is required.

Urine, in its natural state, is transparent, of a citron
yellow colour, a peculiar smell, and a saline taste.

It is more or less abundant, according to the seasons,
and the state of the individual. It is sufficient to observe,
on this subject, that transpiration, and more especially per-
spiration or sweat, supply the place of the secretion of
urine; and that, consequently, when the transpiration is
great, the urine is not abundant.

Physicians distinguish two kinds of urine. The one
is emitted one or two hours after drinking; this is aque-
ous, contains scarcely any salts, and has neither colour
nor smell: it is this which is evacuated so plentifully
during a course of mineral waters. The other is not eva-
cuated until after the functions of sanguification are finish-
ed; and may be call Fæces Sanguinis. This has all the
characters we have enumerated and assigned to urine.
It is carried by the arteries into the kidneys, where it is
separated, and poured into the receptacles of these organs,
whence it passes, by the ureters, into the bladder; where
it remains a longer or shorter time according to the habi-
tude of the person, the nature of the urine, the irrita-
bility or magnitude of the bladder itself.

The urine has been long considered as an alkaline fluid;
but in our time it has been proved to contain an excess of
acid. It appears from the experiments of M. Berthollet
—1. That this acid is of the nature of the phosphoric
acid. 2. That the urine of gouty persons contains less
of this acid; whence he conjectures, with reason, that
this acid retained in the blood, and conveyed into the ar-
ticulations, produces an irritation, and consequently a flux
of humours, which cause pain and swelling.

The analysis of urine by distillation has been accurately
made by various chemists, but more especially by Rou-
elle the younger. Much phlegm is obtained, which pu-
trefies with the greatest facility, and affords ammoniac by
its putrefaction, though it does not itself contain that sub-

stance. At the same time a substance is precipitated of an earthy appearance, but which in reality is a true phosphate of urine. It is this same salt which forms the sediment of urine, which is observed by exposing it to cold during the winter, even though the urine be of a person in perfect health. When urine has, by a sufficient evaporation, acquired the consistence of syrup, it need only be exposed, in a cool place, to obtain crystals, in which analysis has proved the existence of the phosphates of soda and of ammoniac. This precipitate of crystals has been distinguished by the name of fusible salt, native salt, microcosmic salt. Urine may be deprived of all saline matter by repeated solutions, filtrations, and evaporations; the matter which adheres to these crystals, and of which they may be cleared by these operations, is soluble, partly in alcohol, and partly in water. The saponaceous substance, or that which is soluble in alcohol, is capable of crystallization, dries difficultly, and affords by distillation a small quantity of oil, of carbonate of ammoniac, of muriate of ammoniac, and the residue converts syrup of violets to a green. The extractive principle is easily dried, and exhibits the same phenomena in distillation as animal substances. See Rouelle.

The phenomena exhibited by the spontaneous decomposition of urine, are very interesting to be known; on which subject an excellent memoir of Mr. Halle in the volume of the Society of Medicine for 1779, may be consulted. Urine left to itself soon loses its smell, which is succeeded by a smell of ammoniac, which is likewise dissipated in its turn. The colour becomes brownish, and the smell fetid and nauseous. We are indebted to Mr. Rouelle for a valuable observation—that crude urine *urina potus*, presents very different phenomena; and that it becomes covered with mouldiness, like the expressed juices of vegetables. Putrefied urine has much less acid in the disengaged state than when it is fresh.

The fixed alkalis and lime disengage much ammoniac from urine by decomposing the phosphate of ammoniac.

The acids destroy the smell of urine by combining with the ammoniac, which is the principal vehicle of that smell.

We may therefore consider urine, in its natural state, as water holding in solution matters purely extractive, and phosphoric or muriatic salts. These phosphoric salts have

lime, ammoniac, or soda, for their basis : we shall take a slight view of each in particular.

That which is called fusible salt, is nothing but a mixture of all the salts contained in urine, clogged with the extractive principle. All the ancient chemists advised evaporation and repeated filtration, to clear them from this animal extract; but Messrs. Rouelle and the Duke de Chaulnes have observed, that great part of the salt is disengaged and dissipated by these operations to such a degree, that three-fourths are lost. To avoid most of this loss, the Duke de Chaulnes advises solution, filtration and cooling in well-closed vessels. Two strata of salt are then obtained; the upper of which appears to have the form of square tables, wherein Rouelle observed tetrahedral prisms flattened with dihedral summits. This is the phosphate of soda : and beneath this lies another salt crystallized in regular tetrahedral prisms, and is the phosphate of ammoniac.

1. The phosphate of ammoniac usually exhibits the form of a very compressed tetrahedral rhomboidal prism : but this form varies much; and the mixtures of the phosphate or muriate of soda cause an infinity of modifications in it.

The taste of this salt is cool, afterwards urinous, bitter and pungent.

This salt swells up upon the coals, emits a strong smell of ammoniac, and melts by the blow-pipe into a very fixed and very fusible glass.

It is soluble in water. Five parts of cold water, at ten degrees of Reaumur, dissolved only one of this salt ; but at the temperature of sixty degrees this salt is decomposed, and a portion of its acid is volatilized.

It serves as a flux to all the earths ; but in this case its alkali is disengaged, and the phosphoric acid unites with the earth, as I find by experiment. Bergmann proposed it as a flux. The fixed alkalis and lime-water disengage the ammoniac.

When this salt is heated with charcoal, it affords phosphorus.

2. The phosphate of soda was made known in 1740 by Haupt, under the name of sal admirabile perlatum. Hellot before him, and Pott seventeen years after him,

took it for selenite. Margraff gave an accurate description of it in his Memoirs, in 1745; and Rouelle the younger described it at full length in 1776, under the name of fusible salt with base of natrum. All agree that it differs from the preceding in not affording phosphorus with charcoal.

According to Rouelle, its crystals are flattened irregular tetrahedral prisms, with dihedral summits. The four sides of the prism are two irregular alternate pentagons, and two long rhombi truncated slopewise.

When exposed to heat it fuses, and affords a glass which becomes opaque by cooling.

It is soluble in distilled water, and the solution turns syrup of violets green.

It does not afford phosphorus with charcoal.

Lime disengages the soda. It may even be obtained in a caustic state, if the precipitation be effected by lime-water.

The mineral acids, or even distilled vinegar, decompose it by seizing its alkali. Mr. Proust, to whom we are indebted for all the accurate information we possess concerning these substances, was of opinion, that the base to which the soda adhered was not the phosphoric acid, but a very singular salt, whose properties greatly resembled those of the acid of borax. He found this salt in the mother water, after having decomposed the phosphate of soda by the acetous acid, and obtained the acetite of soda by crystallization. He obtained this same salt by dissolving and evaporating the residue of the distillation of phosphorus. One ounce of phosphoric glass contains five or six drams. This salt was characterized by the following properties:

1. It crystallizes in parallelograms.

2. Its taste is alkaline, and it turns syrup of violets green.

3. It swells up in the fire, reddens, and melts.

4. It effloresces in the air. This may not take place when the phosphoric acid has not been sufficiently decomposed by the distillation to leave the alkali disengaged, as I have observed.

5. Boiling water dissolves six gross per ounce.

6. It assists the vitrification of earths, and forms a perfect glass with silex.

7. It decomposes nitre and marine salt, and separates their acids.

8. It is insoluble in alcohol.

Mr. Klaproth has published in Crell's Journal an analysis of the fusible salt, in which he has shewn that the pearly salt, or salt of Proust, is merely the phosphate of soda. To prove this nothing more need to be done than to dissolve this salt in water, and to add a solution of nitrate of lime. The nitric acid seizes the soda, and the phosphoric acid is precipitated with the lime. The phosphoric acid may afterwards be separated by means of the sulphuric acid.

If the phosphoric acid obtained by the slow combustion of phosphorus be saturated with soda slightly in excess, the fusible salt is formed; if this excess be taken up by vinegar, or if more phosphoric acid be added, the substance described by Proust is formed.

The phosphate of soda is not decomposable by charcoal; and it is at present clearly seen why the fusible salt affords but little phosphorus; and why Kunckel, Margraff and others recommended a mixture of the muriate of lead: for by this means the phosphate of lead was formed, which permits the decomposition of the phosphoric acid, and affords phosphorus.*

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* The most economical mode of preparing the phosphate of soda, is the following.

Take three parts of bones calcined to whiteness, powdered and sifted, mix them with water to a thin consistence, and add one part of the sulphuric acid, stirring them well together. An effervescence will take place, owing to the carbonic acid disengaged from the carbonate of lime, contained in the bone ash, and the whole presently becomes very thick. Add more water till it is again reduced to a very thin liquid, and either leave the materials together for two or three days, frequently stirring them, or the operation may be shortened by heating the mixture four or five hours. Then filter through linen, wash the insoluble part with hot water repeatedly, and add all the washings to the first filtered liquor. Saturate this liquor with carbonate of soda added to excess, whereby some phosphate of lime is precipitated; boil and filter again, and then evaporate the clear solution considerably but not to a pellicle: by cooling, fine crystals of phosphate of soda will form. The mother water is then to be examined; if acid, more carbonate of soda must be added, if a little alkaline, the evaporation must simply be continued, but if too much so, some of the ori-

Concerning the Calculus of the Bladder.

Paracelsus made some researches concerning the calculus of the bladder, which he calls duelech. He considers it as a substance intermediate between tartar and stone, and thinks that its formation is owing to the modification of an animal resin: he supposes it to be absolutely similar to the matter of the gout.

Vanhelmont does not admit of this analogy ; and considers the calculus as an animal coagulum produced by the salts of urine, and a volatile earthy spirit. Boyle found this calculus to be composed of oil and volatile salt. Boerhaave supposed it to consist of a subtle earth, intimately united with alkaline volatile salts. Hales has observed that a calculus of the weight of two hundred and thirty grains afforded six hundred and forty-five times its volume of air, and that there remained only a calx of the weight of forty-nine grains.

Independent of this chemical information, some physicians, such as Alston, De Haen, Vogel, Meckel, &c. had observed the solvent power of soap, lime-water, and alkalis.

But we possessed no accurate ideas on this subject until it was seriously taken up by Scheele and Bergmann. The bezoar of the bladder is formed for the most part of a peculiar concrete acid, which M. De Morveau calls the Lithiasic Acid. (The Encyclopedie Methodique may may be consulted, from which the present article is an extract.)

ginal acid liquor is to be added, (and therefore a small portion should be reserved in the first instance, before the carbonate of soda is added, and by further evaporation and crystallization, an additional portion of phosphate of soda may be procured whilst any of the mother liquor remains.

From 2100 parts of calcined bones treated by 700 parts of sulphuric acid, 667 parts of carbonate of soda will be required for complete saturation, and from these materials 855 parts of phosphate of soda will be procured.*—*Am. Ed.*

* Annales de Chimie. tom. xxxix. p. 269.

The calculus is partly soluble in boiling water. The lixivium reddens the tincture of turnsol; and by cooling deposites most of what it had dissolved. The crystals thus separated are the concrete lithiasic acid.

Scheele has likewise observed—1. That the sulphuric does not dissolve the calculus unless assisted by heat, and that it is then converted into the state of sulphureous acid. 2. That the muriatic acid has no action upon it. 3. That the nitric acid dissolves it with effervescence, and disengages nitrous gas and carbonic acid. This solution is red; it contains a disengaged acid, and tinges the skin of a red colour. This solution is not precipitated by the muriate of barytes, nor rendered turbid by the oxalic acid. 4. That the calculus was not attacked by the carbonate of potash; but that the caustic alkali dissolved it, as well as the volatile alkali. 5. That one thousand grains of lime-water dissolved 5,37 by mere digestion, and that it was again precipitated by acids. 6. That all urine, even that of infants, held a small quantity of the matter of calculus in solution; which may perhaps be the cause that when this matter finds a nucleus in the bladder, it more easily encrusts it. I have seen a calculus with a large plum stone in its centre. 7. That the brick-coloured deposition from the urine in fevers, is of the nature of the calculi.

These experiments exhibit several important consequences with regard to the composition of the calculus, and the properties of the lithic acid.

The calculus contains a small quantity of ammoniac. The coaly residue of the combustion indicates animal substance of the nature of jelly. The celebrated Scheele did not find it to contain a particle of calcareous earth; but Bergmann precipitated a true sulphate of lime, by pouring the sulphuric acid into the nitrous solution of the calculus. He admits that the lime is very small in quantity, as it rarely exceeds the two-hundredth part of the entire weight. The same chemist has detected a white spongy substance, not soluble in water, nor attacked by spirit of wine, or acids, or alkalis; which at last affords a coal of difficult incineration, and which the nitric acid does not dissolve, even in the state of ashes; but this

matter exists in so small a quantity, that he could
not procure enough to examine it.   The calculus is
not therefore analogous to bones in its nature; neither
is it a phosphate of lime, as has been pretended. These
are the results of the chemists of the north; but I must
observe that, after having decomposed many calculi by the
caustic alkali, I have precipitated lime and formed phos-
phates of potash.

Some physicians, such as Sydenham, Cheyne, Murray,
&c. have thought that the arthritic concretions were of
the same nature as the calculus.   The use of which
Boerhaave made of alkalis in the gout; the virtues
admitted by Fred. Hoffmann in the thermal waters of
Carlsbad, which contain soda, with an excess of car-
bonic acid; the authority of Springsfeld, who asserts
that the calculus is very speedily dissolved in these waters,
even in the urine of those who drink them; the success
of lime-water, used by Alston in the gout—all conspire
to give some credit to the opinion of these early physici-
ans.   But the following experiments do not agree with
this notion.

Vanswieten affirms that the arthritic concretion never ac-
quires the harshness of the calculus.   Pinelli (Philos.
Trans.) distilled in a retort three ounces of the arthritic
matter collected from the articulations of several gouty
persons; and he obtained ammoniac, with some drops of
oil, the residue weighing two gross.   This residue, which
was soluble in the muriatic, sulphuric, and acetous acids,
was not attacked by volatile alkali.   An observation of
Mr. Rœring was published in the Memoirs of the Aca-
demy of Stockholm for 1783, which ascertains that the
concretions expectorated by an old man subject to the
gout, were found to be of the nature of bone, or phos-
phate of lime.   But one of the newest and most import-
ant facts is that of Watson, in the Medical Communicati-
ons of London, vol. i. 1734.   He concludes, from the
examination of the arthritic concretions of a gouty body,
that this substance is very different from the matter
of the calculus, since it is soluble in the synovia, and
easily mixes with oil and water, which the calculus
does not.

It follows from our observations on the lithic acid, that this acid is concrete, and sparingly soluble in water; that it is decomposed, and partly sublimed by distillation. This acid decomposes the nitric acid, unites with earths, alkalis, and metallic oxides. It yields its bases to the weakest vegetable acids, not excepting the carbonic.

CHAPTER I.

Concerning Phosphorus.

PHOSPHORUS is one of the most astonishing products of chemistry. It is pretended that traces of the knowledge of this substance exist in the writings of the earliest chemists : but the most positive information we possess on this subject is found in the history given by Leibnitz, in the Melanges de Berlin for 1710. He gives the discovery to Brandt, a chemist of Hamburg, who during a course of experiments upon urine, with a view of extracting a fluid proper to convert silver into gold, discovered phosphorus in the year 1667. He communicated his discovery to Kraft, who shewed it to Leibnitz; and being afterwards in England, he communicated it to Boyle.* Leibnitz caused the first inventor to be introduced to the Duke of Hanover, before whom he performed the whole operation; and a specimen of the phosphorus was sent to Huygens, who shewed it to the Academy of Sciences at Paris.

* As Boyle communicated the process for making phosphorus to the Royal Society as a discovery of his own, and it is entered as such in the Philosophical Transactions, I cannot avoid animadverting on this impeachment of his integrity, which is copied from one chemical book into another. It is grounded on no better foundation than the assertion of Kraft, a dealer in secrets, who, after having deceived

It is said that Kunckel had associated himself with Kraft to purchase the process from Brandt. But Kunckel having been deceived by Kraft, who kept the secret to himself, knowing that urine was made use of, set to work, and discovered a process for making the substance; and it is this which led chemists to call it by the name of Kunckel's Phosphorus.

Though the process was rendered public, Kunckel, and a German called Godefred Hatwith†, were the only persons who prepared phosphorus for a long time. It was not till the year 1737, that it was made in the laboratory of the Royal Garden at Paris. A foreigner executed this operation in the presence of Messrs. Hellot, Du Fay, Geoffroi, and Du Hamel. An account of the operation may be seen in the volume of the Academy for 1737. Hellot has collected all the essential circumstances. Margraff, in the year 1743, published a new and more easy method, which has been followed until Scheele and Gahn taught us to obtain it from bones.

The process of Margraff consists in mixing the muriate of lead, which remains after the distillation of four pounds of minium and two of sal ammoniac, with ten pounds of the extract of urine of the consistence of honey. Half a pound of charcoal in powder is added; the mixture is dried in an iron pot until it is reduced to a black powder. This powder is to be put into a retort; and the volatile alkali, the fetid oil, and the sal ammoniac, distilled off. The residue contains the phosphorus. It is assayed by throwing a small quantity on hot coals: if it

his friend Kunckel, associated with him for the purchase of this secret. I might insist, in defence of the candour and otherwise unimpeached integrity of Boyle, that his assertion ought infinitely to outweigh that of the other. Not to insist, however, upon this, it may be noticed that this new and famous product was known to have been extracted from urine; that Kunckel is universally admitted as the discoverer, from his having formed it upon no fuller information than this; that Boyle might with equal probability be admitted to have discovered it in the same manner, and upon information equally slight; and that the probability of this is rendered incomparably greater, by the consideration that none of these chemists made any complicated experiments, but merely applied the force of fire to urine until this product at last came over.   T.

† Spelled Hanckwitz by most authors. He was instructed by Boyle.   T.

emits a smell of garlic, and a phosphoric flame, it is to be put into a good earthen retort, and distilled. Much more phosphorus is obtained by this than by the old process; and this depends on the addition of the muriate of lead by Margraff, which decomposes the phosphate of soda, forming a phosphate of lead, which affords phosphorus; whereas the phosphate of soda is not decomposable by charcoal. The famous chemist of Berlin has likewise proved that it was the fusible salt of urine which affords the phosphorus.

Mr. Gahn published, in the year 1769, that the earth of calcined bones consisted of lime united with the acid of urine; but Scheele was the first to prove that by decomposing this salt of bones by the nitric and sulphuric acids, evaporating the residue in which the phosphoric acid exists in a disengaged state, and distilling the extract with powder of charcoal, phosphorus is obtained. These circumstances, related by Bergmann himself in his notes to the Chemistry of Scheffer, attribute to Scheele the discovery of extracting phosphorus from bones. It was not until the year 1775 that the process was published in the Gazette Salutaire de Bouillon. Additions and improvements have been successively made in this process, of which accounts may be seen in the Dictionnaire Encyclopedique.

The process which has most constantly succeeded with me, is the following:

The hardest bones are selected and burned. By this combustion the external part becomes white, while the internal part is blackish.

These burned bones must then be pulverized, and put into a turine, or in a round hooped wooden vessel. Half their weight of oil of vitriol is then to be poured on, and constantly stirred. During the agitation a considerable heat is excited. The mixture must be left in digestion for two or three days; after which, water must be gradually added, and stirred. I digest this last mixture upon the fire, in order to encrease the solvent power of the water.

The water of the lixivium is then to be evaporated in vessels of stone ware, silver or copper. Mr. Pelletier recommends this last metal; because, according to him,

the phosphoric acid does not attack copper. The evapo-
ration must be carried to dryness; more boiling water
must be poured on the residue ; and this washing must
be continued until the matter be exhausted, which may be
known by the water being no longer tinged yellow. All
these waters are to be evaporated, and afford an extract.

To separate the sulphate of lime, the extract must be dis-
solved in the least possible quantity of water, then filtered,
and the salt remains on the filtre. This extract may be mixed
with powder of charcoal, and distilled : but I prefer con-
verting it into animal glass; for which purpose I put the
extract into a large crucible, and urge the fire. It swells
up at first, but at last settles ; and at that instant the glass
is made. This glass is white, of a milky colour. Be-
cher was perfectly acquainted with it : but concealed his
process, on account of the abuses which, according to
him, might be made of it—*propter varios abusus.* He
tells us, in proper terms, *homo vitrum est, et in vitrum
redigi potest, sicut et omnia animalia.* He regrets that
the Scythians, who drank out of disgusting sculls, were
not acquainted with the art of converting them into glass.
He shews that it would be possible to form a series of
one's ancestors in glass, in the same manner as we pos-
sess them in painting, &c.

I observed once, to my great astonishment, that the
phosphoric glass I had just made, emitted very strong
electric sparks : these flew to the hand at the distance of
two inches. I exhibited this phenomenon to my audience
of pupils. This glass lost the property in two or three
days, though preserved in a capsule of common glass.

It sometimes happens that this glass is deliquescent,
but it is then acid ; and this circumstance arises from too
large a quantity of sulphuric acid, or from this acid not
having been saturated by a digestion of sufficient continu-
ance.

I have likewise obtained glass of the colour of tur-
quoise, when I performed the evaporation in copper ves-
sels.

This glass may be deprived of the bubbles it usually
contains, by keeping it for a time in a violent heat ; it is
then transparent, and may be cut like a diamond. Ac-
cording to Crell, its specific gravity is to that of water as

three to one, while that of diamond is as three and a half to one. This glass is insoluble in water, &c. A skeleton of nineteen pounds, burned, affords five pounds of phosphoric glass.

I pulverize this glass, mix it with equal parts of powder of charcoal, put it into a porcelain retort well coated, the beak of which I partly plunge into the water of the receiver, so that nothing can escape but air or phosphoric gas. I adapt a large tube to the tubulure of the receiver, and plunge it into a vessel filled with water. The fire being raised by degrees, the phosphorus comes over the moment the mixture is ignited. The phosphorus sublimes, partly in the form of a fume which congeals; and is precipitated upon the surface of the water, partly in the form of inflammable gas, and partly resembling melted wax, which drops in beautiful transparent tears from the neck of the retort. The theory of this operation is easily explained. The phosphoric acid is displaced by the sulphuric acid, as is shewn by the large quantity of sulphate of lime which is obtained. All the other operations tend only to concentrate this phosphoric acid, which is still combined with other animal substances, and the distillation with charcoal decomposes the phosphoric acid; its oxigene unites with the coal, and affords a carbonic acid, while the phosphorus itself becomes disengaged.

To purify the phosphorus, a piece of chamois leather is moistened, and the mass of phosphorus is put into it. This being immersed in a vessel of boiling water, the phosphorus melts, and is passed through the skin like mercury. The skin cannot be used more than once; the phosphorus, which might be passed a second time, would become coloured. This process was contrived by Mr. Pelletier.

In order to form phosphorus into sticks, a funnel with a long neck may be used, the lower orifice being closed with a small cork, or piece of soft wood. The funnel is then to be filled with water, the phosphorus put in it; and this being plunged in boiling water, the heat is communicated to that of the funnel; and melts the phosphorus, which runs into the neck, and takes that form. The funnel is then removed into a vessel of cold water; and when the phosphorus is perfectly cooled, the cork is taken

out, and the phosphorus thrust out of its mould with a small piece of wood.

Phosphorus is kept under water. After a certain time it loses its transparency, becomes covered with a white powder, and the water is acidulated.*

In whatever manner phosphorus may be made, it is always one and the same substance, characterized by the following properties :—It is of a flesh colour, and evidently transparent. It has the consistence of wax ; and may be cut in pieces with a knife, or twisted asunder with the fingers ; in which last case the precaution must be taken of frequently plunging it into water, to prevent its taking fire.

When phosphorus is placed in contact with the air, it emits a white fume. It is luminous in the dark : and a solid stick of phosphorus may be used to write with, like a crayon. The marks are visible in the dark ; and by this means has often been used to create fear and astonishment in the minds of the ignorant.

When phosphorus is exposed to twenty-four† degrees of heat, it takes fire with decrepitation, burns with a very bright flame, and emits a very abundant white fume which is luminous in the dark. The residue of the combustion is a red caustic substance, which attracts the humidity of the air, and becomes resolved into a liquor. This is the phosphoric acid, which we shall proceed to treat of.

Mr. Wilson affirms that the solar rays set fire to phosphorus ; and proves that this flame has the colour proper to the phosphorus, and not that of the ray itself.—Letter of Mr. Wilson to Mr. Euler, read at the Royal Society of London in June 1779.

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* This slow acidification of the phosphorus seems to be reversed by the sun's light. Sticks of phosphorus, which had become covered with a white powder, were exposed under water to the sun's light, which converted them to an orange yellow colour in such parts as were acted upon by the direct light. This fact appears to be of the same nature as the colouring of the nitric acid, and other similar phenomena. T.

† Twenty-four degrees of Reaumur answer to eighty-six of Fahrenheit. The vivid combustion of phosphorus takes place at different temperatures, according to its purity ; but the present is very low. By taking phosphorus into a freezing atmosphere, its faint flame disappears, and it seems to require a temperature of sixty degrees to revive it. I found the vivid combustion to take place at one hundred and sixty degrees. T.

An advantageous use has lately been made of the combustible property of phosphorus, to procure fire conveniently, and in all situations, by means of phosphoric tapers or matches, and the philosophical bottles, the method of making which we shall point out.

1. The most simple process for making the phosphoric matches, consists in taking a glass tube, four inches long, and one line in diameter, closed at one end. A small quantity of phosphorus is introduced into the tube, and pushed to its further end; after which a taper covered with a small quantity of wax is introduced into the same tube. The open end is then hermetically sealed, and the other end is plunged into boiling water. The phosphorus melts, and fixes itself upon the match.

A line is drawn at one third of the length of the tube, with a flint, that it may be broken as occasion may require.

The match is to be drawn out quickly, to inflame the phosphorus.

The process of Mr. Lewis Peyla, to make the inflammable bougies, consists in taking a glass tube, five inches long and two lines wide, one end of which is sealed with the blow-pipe. Small tapers of wax are prepared with three double threads of cotton twisted together. The extremity of the match or taper is half an inch long, and must not be covered with wax.

A piece of lead is laid in a saucer filled with water; and upon this the phosphorus is cut, beneath the water, into fragments of the size of a grain of millet. One of these grains is to be dried, and introduced into the tube of glass; after which the fortieth part of a grain of very dry sulphur is to be added, that is to say, half the weight of the phosphorus. One of the bougies is then taken, and its extremity dipped in very clear oil of wax. If too large a quantity rises, it must be dried with a cloth.

The match is introduced into the tube with a turning or twisting motion between the fingers.

The bottom of the tube must then be plunged in boiling water, to soften the phosphorus; observing to keep it no longer than three or four seconds in the water.

The other extremity of the tube is afterwards sealed.

These bougies must be kept in a tin tube, to avoid the danger of inflammation.

2. To form the phosphoric bottles, a glass bottle is heated by fixing it in a ladle full of sand, and two or three small pieces of phosphorus are then introduced into it. A small red hot iron wire is used to stir the phosphorus about, and cause it to adhere to the internal surface of the bottle, where it forms a reddish coating. The heated wire is introduced repeatedly; and when all the phosphorus is thus distributed within the bottle, it is left open for a quarter of an hour, and afterwards corked. When this is used, a common match tipped with sulphur is introduced into the bottle, turned round, and quickly drawn out. The phosphorus which sticks to the sulphur takes fire, and lights the match.

The theory of this phenomenon depends on the circumstance that the phosphorus is strongly dried, or half calcined, and needs only the contact of air to set it on fire.

Phosphorus is soluble in oils, more especially the volatile oils, which then become luminous. If this solution be kept in a bottle, a phosphoric flash, which emits a small quantity of light, will be seen every time the bottle is opened. The oil of cloves is used in this operation. The combination of phosphorus and oil appears to exist naturally in the glow-worm, lampyris splendidula Linnæi. Forster of Gottingen observes, that the shining matter of the glow-worm is liquid. If the glow-worm be crushed between the fingers, the phosphorescence remains on the finger. Henckel reports, in the eighth dissertation of his Pyritologia, that one of his friends, of a sanguine temperament, after having danced much, perspired to such a degree that he thought his life in danger. While he undressed, traces of phosphoric flame were seen on his shirt, which left yellow red spots behind them, resembling the residue of burned phosphorus : this light was long visible.

A phosphoric gas may be extracted from phosphorus, which takes fire by the mere contact of the air. Mr. Gengembre has shewn the method of extracting it, by digesting alkalis upon it (Memoir read to the Academy at Paris the 3d of May 1783); and at the same time I shewed that it might be extracted by means of acids, which are decomposed upon phosphorus. I have likewise taken notice, in my Memoir upon the decomposition of the nitric acid by phosphorus, that when the acid

is digested upon it, a gas escapes, which takes fire in the receiver, and has several times afforded me the appearance of flashes of lightning striking through the cavity of the vessels. But this phenomenon disappeared as soon as the vital air was absorbed.

It is to the disengagement of a gas of this nature that we may attribute the ignes fatui which play about burying grounds, and generally in all places where animals are buried and putrefy. It is to a similar gas that we may refer the inflammable air which constantly burns in certain places, and upon the surface of certain cold springs.

Phosphorus is found in the three kingdoms. Mr. Gahn found the phosphoric acid in lead. Siderite is a phosphorus of iron. The seeds of rocket, of mustard, of garden cresses, and of wheat, treated by Margraaff, afforded him a fine phosphorus. Mr. Meyer of Stetin has announced, in the Chemical Annals of Crell for the year 1784, that the green resinous part of the leaves of plants contains the phosphoric acid. Mr. Pilatre du Rozier renewed the opinion of Rouelle in 1780 (Journal de Physique for November), who considered the phosphoric acid as analogous to that of mucilaginous bodies; and he affirms that the distillation of pyrophorus affords five or six grains of phosphorus in the ounce. The phosphoric acid exists in urine, bones, horns, &c. M. Maret, by treating twelve ounces of beef by combustion, obtained three gross of transparent phosphoric glass. M. Crell obtained it from beef suet and human fat; M. Hankwitz from excrements; Leidenfrost from old cheese; Fontana from fishes' bones; Berniard from egg shells, &c. Messrs. Macquer and M. Struve found the phosphoric acid in the gastric juice.

The most interesting combination of phosphorus is that which it forms with vital air. This is always the phosphoric acid; but the acid appears to be modified by the manner in which it is made.

Phosphorus unites with oxigene—1. By deflagration, or the rapid combustion. 2. By the slow combustion. 3. In the humid way, more especially by the decomposition of the nitric acid.

1. If phosphorus be exposed to a dry heat of twenty-four degrees, it takes fire, emits a white dense fume, and leave a reddish residue, which powerfully attracts the humidity of the air and becomes resolved into a liquor. This combustion may be performed under glass vessels; in which case white flocks are deposited on the sides of the glass, which resolve into a liquor by the contact of moist air, and form the phosphoric acid. Care is taken to introduce an additional quantity of vital air when the combustion of the phosphorus has not been completed.

M. Lavoisier has burned phosphorus, by the assistance of a burning glass, under a glass vessel plunged in mercury (Memoirs of the Royal Academy of Sciences, 1777.)

Margraaf had observed that air is absorbed in this operation. M. Morveau, in the year 1772, had declared the same from his own experiments; and Fontana proved that phosphorus absorbs and vitiates air, like every other combustible substance. Messrs. Lavoisier and De la Place found that forty-five grains of phosphorus absorbed 65,62 of vital air.

The acid obtained by this means is impure. It always contains phosphorus in solution, not saturated with oxigene.

2. Phosphorus is most completely decomposed by the slow combustion. For this purpose the neck of a glass funnel is inserted into a bottle, and sticks of phosphorus are disposed round in the funnel, so as not to touch each other; a small piece of glass tube being put into the neck, to prevent their falling through. A paper is tied over the funnel. The phosphorus is slowly decomposed; and, as it becomes converted into a fluid, it flows into the bottle, where it forms a liquid without smell or colour. This acid almost always retains a small quantity of undecomposed phosphorus, from which it may be cleared by digesting alcohol upon it, which dissolves the phosphorus, without volatilizing the acid.

One ounce of phosphorus produces in this manner three ounces of phosphoric acid.

3. The nitric acid may be decomposed by digestion upon phosphorus. The nitrous gas is dissipated; and the oxigene remains united to the phosphorus, with which it forms phosphoric acid. When the nitric acid is very concentrated, the phosphorus takes fire, and burns at its surface. I published this process, with all the circumstances of the operation, in 1780, the same year in which the excellent Memoir of M. Lavoisier on the same question was printed, and of which I had then no knowledge.

The water in which phosphorus is kept, contracts acidity in the course of time; which shews that the water itself is decomposed, and yields its oxigene to the phosphorus.

Phosphorus precipitates some metallic oxides from their solutions in the metallic state. It is observed that acid is formed in this operation; which proves that the oxigene quits the metal to unite with the phosphorus.

The phosphoric acid is clear, inodorous, without being corrosive. It may be concentrated to dryness. Crell having concentrated it to dryness, found its specific gravity, compared with water, to be as 3. 1.

This acid is very fixed. If it be concentrated in a matrass, the water is first dissipated, a smell of garlic is soon perceived, which arises from a portion of phosphorus from which this acid is difficultly cleared: and vapours likewise rise. The liquor becomes turbid, assumes a milky appearance, and a pasty consistence; and if the matter be put into a crucible, on hot coals, it boils considerably. The vapour which issues renders the flame green; and the mass at last becomes converted into a white transparent glass insoluble in water.

The phosphoric acid has no action on quartz.

It dissolves clay with ebullition.

It dissolves barytes; and unites to clay with singular facility, with which it forms a salt of sparing solubility. The solution when well charged, lets fall, at the end of four and twenty hours, crystals in small thin flattened needles, several lines long, and obliquely truncated at each end. The phosphoric acid precipitates lime from lime-

water, and forms a true phosphate of lime, very similar
to the basis of bones, and decomposable by the mineral
acids like that substance.

The phosphoric acid, saturated with potash, forms a
very soluble salt, which affords tetrahedral crystals termi-
nating in tetrahedral pyramids. This phosphate is acid,
swells up on hot coals, and is difficult of fusion. Lime-
water decomposes it.

Soda, combined with the phosphoric acid, affords a
salt of a taste resembling that of the muriate of soda,
This phosphate does not crystallize, but becomes convert-
ed into a gummy and deliquescent mass by evaporation.
M. Sage affirms that phosphate of soda prepared with the
acid of the slow combustion, forms a salt susceptible of
crystallization.

Dr. George Pearson has combined the phosphoric acid
obtained by nitric acid with soda, and obtained a neutral
salt in rhomboids.

This salt, though saturated, turns syrup of violets
green, effloresces in the air, and has a saline taste resem-
bling that of common salt. It purges in the dose from
six to eight drams, without producing either nausea or
griping, and has not a disagreeable taste.

The phosphoric acid acts only on a small number
of metallic substances. On this subject the works
of Messrs. Margraaf and De Morveau may be con-
sulted.

The phosphoric acid has a very evident action on oils.
Mixed with an equal portion of olive oil, it acquires a
fawn colour by mere agitation, which subsists even after
the separation. This shade increases if the two fluids be
digested together; the acid becomes thick; and the oil
which floats above becomes black and coaly, and emits
a strong smell.

CHAPTER X.

Concerning certain Substances obtained from Animals for the Use of Medicine and the Arts.

THERE is not perhaps any animal product whose virtues have not been celebrated by some of the physicians; and there are few animals which have not at some time or other been mentioned as contributing to the advantage of medicine. Time however has happily condemned to oblivion those productions which ought never to have possessed celebrity : and we shall accordingly, on the present occasion, attend only to such as experience has shewn to possess the virtues and powers attributed to them.

We shall not therefore treat of the lungs of the fox, the liver of the wolf, the feet of the elk, the jaws of the carp, the nests of the swallow, the powder of the toad, the dung of the peacock, the heart of the viper, the fat of the badger, nor even that of the hanged malefactor.

Various quadrupeds, cetaceous animals, birds, and fishes, afford products in which chemical and medical experience has ascertained very evident virtues.

ARTICLE I.

Concerning the Products afforded by Quadrupeds.

Under this article we shall treat of the products most in use which are extracted from quadrupeds. These are castoreum, musk, and hartshorn.

1. The name of Castoreum is given to an unctuous fluid contained in two pouches situated in the inguinal region of the male or female castor. An accurate description of it may be seen in the Encyclopedie. This very odorant substance is soft, and nearly fluid when recently extracted from the animal; but it dries in the course of time. It has an acrid, bitter, and nauseous taste; and its smell is strong, aromatic, and even stinking.

Alcohol dissolves a resin which colours it; water extracts an abundant principle. By evaporation of the water a salt is obtained, the nature of which is little known. Castoreum affords by distillation a small quantity of volatile oil, ammoniac, &c.

The uses of castor in the œconomy of the animal are unknown. The ancients had the credulity to believe that the creature itself took it when its stomach was weak.

It is used in medicine as a powerful antispasmodic, in the dose of a few grains in substance; and it enters as a component part into boluses, extracts, &c. It is advantageously joined with opium; and its spirituous tincture is also prescribed in suitable liquids, in a dose from twenty-four to thirty-six drops.

We see clearly, from the little chemical information we possess respecting this substance, that it is a resin joined with a mucilage, and a salt which facilitates the union of its principles.

2. The name of Musk is given to a perfume obtained from various animals. In 1726 an animal was received, under the name of the Musk Animal, in the Royal Menagerie, which came from Africa, and resembled the civet. Mr. Perrault has left a description of it. It was supported six years upon raw flesh. M. De la Peyronnie gave a very good description of it to the Academy of Sciences for the year 1731.

The organ which contained the musk was situated near the genital parts. It was a female. At the aperture of the bag which contained the musk the smell was so strong, that M. de la Peyronnie could not inspect it without inconvenience. This liquor is prepared by two glands, which transmit it into the common reservoir through a number of small perforations.

The other animal which affords musk in the East, is of the class of squirrels. It is very common in Chinese Tartary. It carries the musk in a bag beneath the navel. This bag, projecting outwards of the size of a pullet's egg, is formed of a membranous and muscular substance, provided with a sphincter. Many glands are observable within, which separate the humour. As soon as the beast is killed, this bladder is cut off and tied up: but its contents are adulterated with the testicles, the blood, and other offals of the animal; for each creature affords no more than three or four gross. Musk must be chosen soft, unctuous, and odorant; and ought to be consumed totally upon hot coals. The musk of Tonquin, which is most esteemed, is contained in bags covered with brown hair; but that of Bengal is covered with white hair.

Musk contains nearly the same principles as castoreum. The smell of pure and unmixed musk is too strong and oppressive. It is rendered mild by mixture with other substances. It is little used in medicine; is a powerful antispasmodic in some cases; but ought to be administered with caution, because it often excites nervous affections instead of calming them.

The smell of musk predominates in certain animals. M. De la Peyronnie knew a man from whose left arm-pit there was emitted so strong a smell of musk during the summer, that he was obliged to weaken it to avoid inconvenience.

3. Hartshorn affords several products which are much employed in medicine. The preference is given to this horn because it contains less earthy salt than bones; but all kinds of horn may be used indiscriminately.

Hartshorn was formerly calcined with the greatest care, and used as a remedy against alvine fluxes.

The products of hartshorn which are mostly used at present, are those obtained by distillation. An alkaline phlegm is first obtained, which is called the Volatile Spirit of Hartshorn. Next comes over a reddish oil, more or less empyreumatic; and a very great quantity of carbonate of ammoniac, soiled and coloured by the empyreumatic oil. The oil which colours the salt may be disengaged by means of spirit of wine, which dissolves it. The coaly residue contains natrum, sulphate, and phosphate of lime.

from which phosphorus may be obtained by the processes already described.

The spirit and the salt obtained from hartshorn are used in medicine as good antispasmodics.

The oil duly rectified forms the animal oil of Dippel. As the highest virtues have been attributed to this substance, a thousand methods have been attempted to purify it. For a long time it was usual to rectify it a great number of times, in order to have it white and fluid. But Messrs. Model and Baumé have advised taking only the first portion which comes over, because this is the most attenuated, and the whitest. Rouelle advises distillation with water; and as the most volatile part only rises with the heat of boiling water, there is a certainty of having it very fine by this means. For my part, I distil the empyreumatic oil with the earth of Murviel, which retains all the colouring part; and by this means I have it at once white and attenuated.

This is odorant, and has all the properties of the volatile oils : but it turns syrup of violets green, as Mr. Parmentier has observed ; which proves that it retains a small quantity of volatile alkali. This oil is used in doses of a few drops in nervous affections, epilepsy, &c. It is used externally, by rubbing it on the skin, as a sedative, and to remove obstructions ; but the great virtues formerly attributed to it are not much credited at present.

ARTICLE II.

Concerning certain Products afforded by Fishes.

The oil of fish, and spermaceti, are the most used among the products obtained from fishes.

Spermaceti is a concrete oil extracted from the cachelot. The name of Spermaceti is very improper. These animals are of a prodigious size, and afford large quantities of this matter. Plomet relates that in 1688 a Spanish ship took a whale whose head afforded twenty-four barrels of brains, and the body ninety-six barrels of fat. This spermaceti is always mixed with a certain quantity of inconcrescible oil, which is carefully removed.

Spermaceti burns with a very white flame. It is made into candles at Bayonne and at St. Jean de Lutz. These candles are of a shining white colour, become yellow in process of time, but not so soon as wax and the dense oils.

If it be distilled on a naked fire, it does not afford an acid phlegm, but rises totally, at the same time that it assumes a reddish tinge. Several repeated distillations deprive it of its natural consistence.

The sulphuric acid dissolves it; and this solution is precipitated like the oil of camphor. The nitric and muriatic acids have no action upon it.

Caustic alkali dissolves spermaceti, and forms a soap which gradually acquires solidity.

Alcohol dissolves spermaceti by the assistance of heat, but lets it fall as it cools. Ether likewise dissolves it.

The fixed and volatile oils dissolve it by the assistance of heat.

This substance was formerly much used. It was given as an emollient, and softening remedy; but at present it is almost forsaken, and not without cause; for it is heavy, insipid, and nauseous.

The egg, the scales, and the black fluid of the cuttle-fish are still used in medicine. The eggs deterge the kidneys, and excite urine and the courses. The scales and bones of the cuttle-fish are applied to nearly the same uses: they are likewise used as an astringent; and enter into dentifirice powders, collyria, &c. The goldsmiths likewise use them to make their moulds for casting spoons, forks, toys, &c. because its spongy part easily receives the impression of metals. The black humour of the cuttle-fish, which is found in a bag near the cœcum, and of which Mr. Le Cat has given a description, may be used instead of ink. We read in the Satires of Persius that the Romans used it as an ink; and Cicero calls it Atramentum. It seems that the Chinese use it as the basis of their famous ink. " Sepia piscis est qui habet succum nigerrimum, instar atramenti, quem Chinenses cum brodio orizæ, vel alterius leguminis, inspissant et formant, et in universum orbem transmittunt, sub nomine Atramenti Chinensis." (Pauli Hermani Cynosura, t. i. p. 17, par. 2). Pliny was of opinion that the black humour of the

VOL. II.   3 H

cuttle-fish was its blood. Rondelet has proved that it is the bile. This is the fluid the cuttle-fish disgorges when in danger : a very small quantity is sufficient to blacken a large quantity of water.

Calcined oyster shells are likewise used in medicine as an absorbent.

The oil extracted from fish is of the greatest use in the arts.

ARTICLE III.

Concerning certain Products afforded by Birds.

Most of the birds are used at our tables as a delicate food, but few afford any medical products. The eagle stones, to which so much virtue had been attributed for facilitating labours, the plasters of swallows' nests, and other similar substances, have all fallen into neglect, as the natural consequence of the observation of matter of fact being substituted in the place of credulity and superstition. The analysis of eggs begins to be known. They consist of four parts : an osseous covering, called the shell; a membrane which covers the constituent parts of the egg ; the white; and the yolk, which occupies the centre.

The shell, like bones, contains a gelatinous principle, and the phosphate of lime.

The white is of the same nature as the serum of blood. It renders syrup of violets green, and contains uncombined chalk ; heat coagulates it ; by distillation it affords a phlegm which easily putrefies ; it becomes dry like horn; and carbonate of ammoniac, and empyreumatic oil, come over. A coal remains in the retort, which affords soda, and phosphate of lime. M. Deyeux has also obtained sulphur by sublimation.

Acids and alcohol coagulate it.

If it be exposed to the air in thin leaves, it dries, and becomes consistent; and it is on this property that the custom is founded of passing the white of egg over the surface of paintings, to give them that brightness which is produced by varnish, and also to defend them from the

air. The drying may be hastened by quick-lime; and this mixture affords a lute of the greatest tenacity.

The yolk of egg likewise contains a lymphatic substance, mixed with a certain quantity of mild oil, which on account of this mixture is soluble in water. It is this animal emulsion which is known in France by the name of *lait de poulle.* Yolk of egg exposed to the fire assumes a consistence less hard than the white. If it be bruised, it appears to have scarcely any consistence; and if it be subjected to the press, it gives out the oil it contains. This oil is very emollient, and is used externally as a liniment. There is the greatest analogy between the eggs of animals and the seeds of vegetables; since both contain an oil rendered soluble in water by the admixture of a glutinous substance.

The yolk of egg renders oils and resins soluble; and this substance is accordingly much used for that purpose.

Calcined egg-shells is an absorbent.

White of egg is successfully used to clarify vegetable juices, whey, liquors, &c. It coagulates by heat; and then rises to the surface of these fluids, carrying with it all the impurities they contain.

ARTICLE IV.

Concerning certain Products afforded by Insects.

Millepedes, cantharides, kermes, cochenille, and lac, are the only substances we shall here treat of, because these are not only the most used, but are likewise the best known among the products of insects.

1. Cantharides.—The cantharides are small insects with greenish wings. They are very common in hot countries; and are found on the leaves of the ash, the rose-tree, the poplar, the walnut-tree, the privet, &c.

Cantharides in powder, applied to the epidermis, cause blisters, excite heat in the urine, strangury, thirst, and fever. They produce the same effect taken internally in a small dose. We read in Paré that a courtezan having presented a ragout powdered with cantharides to a young man who supped with her, this unfortunate person was

attacked with a priapism, and loss of blood by the anus, of which he died.   Boyle affirms that pains at the neck of the bladder have been produced by the handling of cantharides.

We are indebted to Mr. Thouvenel for some information respecting the constituent principles of these insects. Water extracts a very abundant principle, which colours it of a reddish yellow, and also a yellowish oily principle. Ether takes up a green very acrid oil, in which the virtue of the cantharides most eminently resides.   So that an ounce of cantharides affords—

	gross.	grains.
Reddish yellow bitter extract	3	0
Yellow oily matter	0	12
Green oily substance, analogous to wax	0	60
Parenchyma, insoluble in water and alcohol	4	0
	8	0

To form a tincture which unites all the properties of cantharides, a mixture must be made of equal parts of water and of alcohol, and the insects digested in it.   If this tincture be distilled, the spirit which comes over retains the smell of cantharides.

If spirit of wine alone be used, it takes up merely the caustic part : hence it appears that the virtue of these insects may be increased or diminished according to the exigence of the case.

The tincture of cantharides may be used with success externally, in the dose of two gross, four gross, one or even two ounces, in rheumatic pains, sciatica, wandering gout, &c.   It heats the parts ; accelerates the circulation; excites evacuations by perspiration, urine, or stool, according to the parts to which it is applied.

Mr. Thouvenel tried upon himself the effect of the green waxy matter.   When applied on the skin in the dose of nine grains, it raised a blister full of serosity.

2. The wood-lice, millepedes, aselli, porcelli.—This insect is usually found in moist places, under stones, or beneath the bark of old trees.   It avoids the light, and endeavours to conceal itself when discovered.   When it

is touched, it rolls up in the form of a globe. This insect is used in medicine as an incisive, aperitive, and alterative remedy. It is prescribed either pounded alive, and put into a proper liquid; or dried and pulverized, in which last form they enter into extracts, pills, &c. The millepedes are given in the dose of fourteen, fifteen, and twenty grains, or more, according to the exigency of the case. Mr. Thouvenel has given us some information concerning the constituent principles of these insects. He obtained by distillation an insipid or alkaline phlegm: the residue afforded an extractive matter, an oily or waxy substance soluble in spirit of wine only, and marine salt with an earthy and an alkaline base.

3. Cochenille.—Cochenille is a substance used in dying scarlet and purple. It is met with in commerce in the form of small grains of a singular figure, mostly convex with little grooves on one side, and concave on the other. The colour of good cochenille is grey mixed with reddish and white. It is at present well determined that it is an insect. Simple inspection with a magnifier sufficiently proves this; and the wings and feet of this insect may be developed by exposing it to the vapour of boiling water, or by digesting it with vinegar. The cochenille is collected in Mexico, upon plants to which the names of Indian Fig, Raquette Nopal, are given. These plants bear fruits which resemble our figs; tinge the urine of those who eat them; and probably communicate to the cochenille the property which makes it useful to the dyer. The Indians of Mexico cultivate the nopal near their habitations, and sow as it were the insect which affords the cochenille. They make small nests of moss or fine herbs, put twelve or fourteen cochenilles into each nest, place three or four of these nests on each leaf of the nopal, and fasten them there by the prickles of the plant: in the course of a few days, thousands of small insects issue out, and fix themselves upon the parts of the leaf which are best sheltered, and afford the most nourishment. The cochenilles are collected several times in the course of the year: and are deprived of life by scalding them, or by putting them into an oven; after which they are dried in the sun. Two kinds of cochenille are distinguished: the one which is produced without culture, and

is called Sylvestre; and the other cultivated, which is called Mesteque. This last is preferred. It has been calculated, in the year 1736, that eight hundred and eighty thousand pounds weight of cochenille was annually imported into Europe. Mr. Ellis has communicated a very good description of the cochenille to the Royal Society of London.

This substance is more especially used in dying: its colour takes readily upon wool; and the most suitable mordant is the muriate of tin. Mr. Macquer has discovered a method of fixing this colour upon silk, by impregnating the silk with a solution of tin before it is plunged into the bath of cochenille; instead of mixing a solution in the baths, as is done for woollens.

4. Kermes is a kind of excrescence, of the size of a juniper-berry, which is greatly employed in medicine and the arts.

The tree which bears it is known by the name of Quercus Ilex. It grows in hot countries; in Spain, Languedoc, Provence, &c. The female of the coccus fixes itself on the plant; it has no wings, but the male has. When she is fecundated, she becomes large by the development of her eggs; she perishes, and the eggs are hatched. It is collected before the development of the eggs; for which purpose, the morning is taken, before the heat has acted upon the eggs. The grains are collected and dried, to develop the red colour; they are then sifted, to separate the powder; and lastly they are sprinkled with good vinegar, to kill the insect, which would otherwise come forth in a short time.

Kermes is much used in the arts: it affords a good red, but less brilliant than that of the cochenille.

A very celebrated syrup of kermes is made, by mixing three parts of sugar with one of the grains of kermes pulverized. This mixture is kept for a day in a cool place: the sugar during this time unites with the juice of the kermes; and forms with it a liquor which, when drawn off by expression, has the consistence of syrup. The celebrated confectio alkermes is made with this syrup.

The grains of kermes given in substance, from half a scruple to a gross or dram, are celebrated for preventing abortion.

The grain and the syrup of kermes are an excellent stomachic.

5. Lac, or gum-lac.—This is a kind of wax, collected by red winged ants from flowers in the East-Indies, which they transport to the small branches of the tree where they make their nests. The nests are full of small cells, in which a red grain is found when the mass is broken. This small grain is, to all appearance, the egg from which the flying ant derives its origin.

Mr. Geoffroy has proved, in a Memoir inserted among those of the Academy for the year 1714, that this must have been a kind of comb, approaching to the honey-comb of bees, the cells of which are formed of a sub-stance analogous to wax.*

The colouring part of lac may be taken up by water, which when evaporated, leaves the colouring principle disengaged. It is the fine lake used for dying. Lake is imitated by extracting the colouring principle of certain plants by well-known processes.

CHAPTER XI.

Concerning some other Acids extracted from the Animal Kingdom.

INDEPENDENT of the acids afforded by the various parts of the human body, which have been separately examined by us, we find acids in most insects.   Lister points out one which may be extracted from millepedes (Collect.   Acad. tom. ii. p. 303).   Mr. Bonnet has ob-

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* For a description and drawing of the insect which affords the lac, consult Keir in the Philos. Trans. vol. lxxi. p. 374 ; also Saunders, in the same work, vol. lxxix. for the method of purifying the lac, or a short abridgment of both, in Nicholson's First Principles of Chemistry, p. 490.   T.

served that the fluid ejected by the great forked-tail cater-
pillar of the willow, was a true acid, and even very active
(Savans Etrangers, tom. ii. p. 276): Bergmann compares
it to the most concentrated vinegar.   The abbé Boissier
de Sauvages has remarked, that in that illness of the silk-
worm, which is called muscardin, the humour of the
worm is acid.   Mr. Chaussier of Dijon obtained an acid
from grasshoppers, from the May-bug, from the lampy-
ris, and several other insects, by digesting them in alcohol.
The same chemist has made an interesting course of ex-
periments on the acid of the silk-worm.   He gives two
methods of extracting it.   The first consists in bruising
the chrysalides, and straining them through a cloth.   The
fluid which passes is strongly acid; but the acid is weak-
ened by various foreign substances, of which it may be
cleared by digestion in spirit of wine.   The fluid which
passes the the filter after this digestion, is of a fine orange
colour.   More spirit of wine is to be poured upon it.   At
every addition of spirit a light whitish precipitate is
formed; and the additions of spirit are to be continued
until no more precipitate appears.

Instead of bruising the chrysalides they may be in-
infused in spirit of wine, which dissolves all the acid;
and as this acid is less volatile than the spirit, this last
may be evaporated, and the residue filtered.   By these
precautions the acid may be cleared of its spirit of wine
and of the mucous matter which was dissolved, but re-
mains on the filter.

Mr. Chaussier has proved that this acid exists in all
the states of the silk-worm, even in the eggs; but that
in the egg and in the worm it does not exist in a dis-
engaged state, but combined with a gummy glutinous
substance.

The acid of insects which is best known, and upon
which most has been written, is the acid of ants, or
the formic acid.   This acid is so far in a disengaged
state, that the transpiration of these animals, and their
simple contact without any alteration, proves its exist-
ence.

The authors of the fifteenth century had observed, that
the flower of chickory thrown into an ant-hill becomes as

red as blood.—See Langham, Hieronimus Tragus, John
Bauhin.

Samuel Fisher is the first who discovered the acid of
ants, in a course of experiments for the analysis of animal
substances by distillation. He even tried its action on
lead and iron; and communicated his observations to J.
Vray, who inserted them in the Philosophical Transactions
in the year 1670. But it was the celebrated Margraaf
who more particularly examined the properties of this
acid in 1749. He combined it with many substances,
and concluded that it greatly resembled the acetous acid.
In 1777 this subject was again resumed by Messrs.
Ardvidsson and Oerhn; and treated in a manner which
leaves little to be desired, in their dissertation published at
Leipsic.

The ant which affords the greatest quantity of acid,
is the large red ant which is found in dry and elevated
places.

The months of June and July are most favourable for
the extraction of this acid: they are then so penetrated
with it, that their simple passing over blue paper is suffi-
cient to turn it red.

Two methods may be used to obtain this acid; dis-
tillation and lixiviation.

To extract the acid by distillation, the ants are first
dried by a gentle heat, and put into a retort, to which a
receiver is adapted, and the fire is raised by degrees.
When all the acid is come over, it is found in the receiver
mixed with a small quantity of empyreumatic oil, which
floats upon it, and may be separated by a funnel.
Messrs. Ardvidsson and Oerhn obtained, in this man-
ner, from each pound of ants, seven ounces and a half
of an acid whose specific gravity, at the temperature of
fifteen degrees, was to that of water as 1,0075 to
1,0000.

In the process of lixiviation, the ants are washed in
cold water; and boiling water is afterwards poured over
them, which is filtered when cold. More boiling water is
poured over the residue, and likewise filtered when cold.
By this means one pound of ants affords a pint of acid
as strong as vinegar, and of a greater specific gravity.

Messrs. Ardvidsson and Oerhn are of opinion that this acid might be substituted instead of vinegar for domestic uses.

The acid obtained by these processes is never pure; but it may be purified by repeated distillations, which disengage the ponderous and volatile oil, and render the acid as clear as water. This acid, when rectified by this process, was found by Messrs. Ardvidsson and Oerhn to have a specific gravity of 1,0011 to 1.

The acid of ants may likewise be obtained by placing linen cloths impregnated with alkali in an ant-hill. From these the formiate of pot-ash, of soda, and ammoniac, may be obtained by lixiviation. The formic acid has some resemblance to the acetous acid; but the identity of these two acids has not yet been proved. Mr. Thouvenel found more analogy between it and the phosphoric acid: but all this wants proof.

The formic acid retains water with so much force, that it cannot be entirely deprived of it by distillation. When it is exceedingly pure, its specific gravity is to that of water as 1,0453 to 1.

It affects the nose and the eyes in a peculiar manner, which is not disagreeable. Its taste is penetrating and burning when pure, but agreeable when diluted with water.

It possesses all the characters of acids.

When boiled with the sulphuric acid, it turns black as soon as the mixture is heated. White penetrating vapours arise; and when it boils a gas is emitted, which unites difficultly with distilled water, or with lime-water. The formic acid is decomposed in this operation, for it is obtained in less quantity.

The nitric acid distilled from it, destroys it completely; a gas arises which renders lime-water turbid, and is difficultly and sparingly soluble in water.

The muriatic acid only mixes with it, but the oxigenated muriatic acid decomposes it.

Messrs. Ardvidsson and Oerhn have determined the affinities of this acid with various bases in the following order: barytes, potash, soda, lime, magnesia, ammoniac, zinc, manganese, iron, lead, tin, cobalt,

copper, nickel, bismuth, silver, alumine, essential oils, water.

This acid mixes perfectly with spirit of wine. It unites difficultly with the fixed oils, and with the volatile oils, by the assistance of heat. It attacks soot; assumes a fawn colour; and lets fall a brown sediment as it cools, which by distillation affords a liquor of a yellowish colour and a disagreeable smell, accompanied with elastic vapours.

CHAPTER XI.

Concerning Putrefaction.

EVERY living body, when once deprived of life, performs a retrograde process, and becomes decomposed. This decomposition is called Fermentation in vegetables, and Putrefaction in animal substances. The same causes, the same agents, and the same circumstances, determine and favour the decomposition of vegetables and animals, and the difference of the productions which are obtained, arises from the difference of the constituent parts of each.

Air is the principal agent of animal decomposition, but water and heat prodigiously facilitate its action. " Fermentatio ergo definitur quod sit corporis densioris rarefactio, particularumque aërearum interpositio : ex quo concluditur debere in aëre fieri nec nimium frigido, ne rarefactio impediatur; nec nimium calido, ne partes raribiles expellantur."—Becher, Phys. Sub. lib. i. s. 5. p. 313. edit. Francofurti.

An animal substance may be preserved from putrefaction by depriving it of the contact of air; and this process may be accelerated or retarded by varying or modifying the purity of the same fluid.

In those circumstances wherein we see putrefaction developed without the contact of atmospherical air, the effect is produced by the water which impregnates the animal substance, which becomes decomposed, and affords the element and the agent of putrefaction. Hence no doubt it arises that putrefaction is observed in flesh closed in a vacuum.—See Lyons, Tentamen de Putrefactione.

Moisture is likewise an indispensable requisite to facilitate putrefaction; and any substance may be defended from this change by completely drying it. This was performed by Villaris and Cazalet of Bordeaux, by means of stoves. The meat thus prepared was preserved for several years without having contracted any bad flavour. The sands and light porous earths preserve the bodies of men only by virtue of the property of exhausting their juices, and drying the solids. From this cause it is that entire caravans have been discovered in Arabia, consisting of men and camels perfectly preserved in the sands under which the impetuous winds have buried them. In the library of Trinity College of Cambridge, in England, a human body may be seen perfectly preserved, which was found under the sand in the island of Teneriffe. Too much humidity impedes putrefaction, according to the observation of the celebrated Becher: " Nimia quoque humiditas a putrefactione impedit, prout nimius calor; nam corpora in aqua potius gradatim consumi quam putrescere, si nova semper affluens sit, experientia docet: unde longo tempore integra interdum submersa prorsus a putrefactione immunia vidimus; adeo ut nobis aliquando speculatio occurreret, tractando, tali modo cadavera anatomiæ subjiciendo, quo diutius a fœtere et putrefactione immunia forent." Phys. Sub. lib. i. s. 5. cap. 1. p. 277.

In order therefore that a body may putrefy, it is necessary that it should be impregnated with water, but not that it should be inundated. It is likewise necessary that this water should remain in the texture of the animal body, without being renewed. This condition is requisite —1. To dissolve the lymph, and to present to the air the most putrescible substance with the greatest extent of surface. 2. In order that the water may itself become decomposed, and by this means afford the putrefactive principle. Putrefaction is retarded and suspended by baking,

because the flesh is dried, and by that means deprived of
the humidity, which is one of the most active principles
of its decomposition.

A moderate degree of heat is likewise a condition fa-
vourable to the animal decomposition. By this heat the
affinity of aggregation between the parts is weakened, and
consequently they assume a stronger tendency to new
combinations. Hence it arises that flesh meat keeps
longer during the winter than the summer, and better in
cold than in hot countries. Beeher has given a very in-
telligent sketch of the influence of temperature on animal
putrefaction : " Aër calidus et humidus maximè ad pu-
trefactionem facit . . . . corpora frigida et sicca difficul-
ter, imo aliqua prorsus non putrescunt, quæ ab imperitis
proinde pro sanctis habita fuere ; ita aër frigidus et sic-
cus, imprimis calidus et siccus, a putrefactione quoque
preservat ; quod in Hispania videmus, et locis aliis calidis,
sicco, calidi aëre præditis, ubi corpora non putrescunt et
resolvantur ; nam cadavera in oriente in arena, imo apud
nos arte in furnis, siccari, et sic ad finem mundi usque à
putredine preservari, certum est : intensumquoque frigus
a prutredine preservare ; unde corpora Stockholmiæ tota
hyeme in patibulo suspensa sine putredine animadverti-
mus." Phys. sub. l. i. cap. 1.

Such are the causes which are capable of determining
and favouring putrefaction ; and hence we may perceive
the best means of preventing, increasing, or modifying it
at pleasure. A body will be preserved from putrefaction
by depriving it of the contact of atmospherical air : for
this purpose nothing more is required than to place the
body in a vacuum, or to envelop it in a covering which
may defend it from the immediate action of the air ; or
else to envelop it in an atmosphere of some gaseous sub-
stance which does not contain vital air. We shall ob-
serve, on this subject, that the effects observed in flesh
exposed in the carbonic acid, nitrogene gas, &c. are re-
ferable to a similar cause ; and it appears to me that it is
without sufficient proof that a conclusion has been drawn,
that these same gases, internally taken, ought to be con-
sidered as antiseptic ; because, in the cases we have men-
tioned, they act only by defending the bodies they sur-
round from the contact of vital air, which is the principle

of putrefaction. Putrefaction may be favoured by keep-
ing bodies at a suitable temperature. A degree of heat
from fifteen to twenty-five degrees diminishes the adhe-
sion of the parts, and favours the action of the air : but
if the heat be greater it volatilizes the aqueous principle,
dries the solids, and retards the putrefaction. It is ne-
cessary, therefore, for the decomposition of an animal—
1. That it have the contact of atmospheric air ; and the
purer this air is, the more speedy will be the putrefaction.
2. That it be exposed to a moderate degree of heat. 3.
That its texture be impregnated with humidity.—The
experiments of Pringle, Macbride, Gardane, have like-
wise shewn us, that putrefaction may be hastened by
sprinkling the animal substances with water containing a
small quantity of salt ; and it is to a like cause that we
ought to refer several processes used in kitchens to pro-
duce this effect in food, as well as in the preparation of
cheese, the curing of tobacco, the making of bread, &c.

Becher expresses himself as follows on the causes
which produce putrefaction in living bodies:—" Causa
putrefactionis primaria defectus spiritus vitalis balsamini
est ; secundaria, deinde, aër externus ambicus, qui inter-
dum adeo putrefaciens et humidus-calidus est, ut super-
stitem in vivis etiam corporibus balsaminum spiritum vin-
cat, nisi confortando augeatur ; ex quo colligi potest,
preservantia a putredine subtilia ignea oleosa esse debere."
—This celebrated chemist concludes, from the same
principles, that ligatures, copious bleedings, or any de-
bilitation whatever, determines putrefaction. He like-
wise thinks that astringents oppose putrefaction only by
condensing the texture of the animal parts ; for he consi-
ders rarefaction or relaxation as the first effect of putre-
faction. He thinks that spirituous liquors act as antipu-
trescent merely by animating and stimulating the vis vitæ.
He affirms that the use of salted meats, which heat much,
assisted by the moisture very common in ships and sea
ports, produces the scurvy ; and he observes, with rea-
son, that the tendency and effect of putrefaction are dia-
metrically opposite to those of generation : " nam sicut
in generatione partes coagulantur et in corpus formantur,
ita in putrefactione partes resolvuntur et quasi informes
fiunt."

As the phenomena of putrefaction vary according to the nature of the substances themselves, and the circumstances which accompany this operation, it follows that it must be very difficult to describe all the phenomena which it exhibits. We shall therefore endeavour to trace only those which appear to be the most constant.

Every animal substance exposed to the air at a temperature above ten degrees of Reaumur, and moistened with its own serous humour, putrefies; and the progress of this alteration appears in the following order.

The colour first becomes pale; its consistence diminishes; its texture becomes relaxed; the peculiar smell of fresh meat disappears, and is succeeded by a faint and disagreeable smell. The colour itself at this time inclines to blue; as we see in game which begins to turn, in wounds which fall into suppuration, in the various parts threatened with gangrene, and even in that putrefaction of the curd which forms cheese. Most of our food suffers the first degree of putrefaction before we use it.

After this first period the animal parts become more and more softened, the smell becomes fetid, and the colour of an obscure brown; the fibrous part easily breaks, the texture becomes dry, if the putrefaction be carried on in the open air ; but the surface becomes covered with small drops of fluid, if the decomposition be made in vessels which oppose its evaporation.

To this period succeeds that which most minutely characterizes animal putrefaction. The putrid and nauseous smell which was manifested in the second degree, becomes mixed with a smell of a more penetrating kind, arising from the disengagement of ammoniacal gas; the mass becomes still less and less consistent.

The last degree of decomposition has its peculiar characters. The smell becomes faint, nauseous, and exceedingly active. This, more especially, is contagious, and transmits the seeds of infection to a great distance : it is a true ferment, which deposites itself upon certain bodies, to appear again at long intervals. Van Swieten reports, that the plague having appeared at Vienna in 1677, and having again appeared in 1713, the houses which had been infected at its first appearance were likewise infected at the second. Van Helmont asserts that a

woman contracted an anthrax at the extremity of her fin-
gers, in consequence of having touched papers impregnat-
ed with pestilential virus.   Alexander Benedictus has
written that pillows reproduced the contagion seven years
after having been infected ; that cords had remained in-
fected for thirty years, and likewise communicated it, ac-
cording to Forestus.   The plague at Messina was for a
long time concentrated in the warehouses where merchan-
dise was inclosed with suspected bales.   Mead has trans-
mitted the most alarming facts concerning the durable
impression of contagion.

When the putrefying substance is in its last stage, the
fibrous texture is scarcely discernible, and has no longer
any appearance but that of soft, disorganized, and putrid
mass.   Bubbles are seen to escape from the surface of
this matter; and the whole ends by its drying, and be-
coming reduced to an earthy matter, which is friable when
taken between the fingers.

We do not speak of the production of worms ; because
it appears to be proved that they owe their origin only to
the flies which endeavour to deposite their eggs upon such
bodies as are best suited to support the young they con-
tain.   If flesh meat be well washed, and left to putrefy
under a sieve, it will pass through all the degrees of pu-
trefaction without the appearance of worms.   It has been
observed that worms are of a different species, according
to the nature of the disease, and the kind of animal which
putrefies.   The exhalation which arises from bodies, in
these different cases attracts different species of insects,
according to its nature.   The opinion of those who be-
lieve in spontaneous generation, appears to me to be con-
trary to the experience and wisdom of nature, which
cannot have committed the reproduction and number of
the species to chance.   The progress of nature is the
same for all the classes of individuals; and since it is
proved that all the known species are reproduced in one
and the same manner, how can we suppose that nature
departs from her plain and general laws for the small
number of individuals whose generation is less known to
us?

Becher had the courage to make observations, during the course of a year, upon the decomposition of a carcass in the open air; and to observe all the phenomena. The first vapour which rises, says he, is subtile and nauseous: some days after, it has a certain sour and penetrating smell. After the first weeks, the skin becomes covered with a down, and appears yellowish; greenish spots are formed in various places, which afterwards become livid and black; a thick mossy or mouldy substance then covers the greatest part of the body; the spots open, and emit a sanies.

Carcases buried in the earth present very different phenomena; the decomposition in a burying-ground is at least four times as slow. It is not perfectly ended, according to Mr. Petit, till three years after the body has been interred, at the depth of four feet; and it is slower in proportion as the body is buried at a greater depth. These facts agree with the principles which we have already established for bodies buried in the earth, and subjected to laws of decomposition very different from those which take place in bodies exposed to the open air. In this case the decomposition is favoured by the waters which filter through the earth, and dissolve and carry with them the animal juices. It is also favoured by the earth, which absorbs the juices with more or less facility. Messrs. Lemery, Geoffroy, and Hunaud have proved that argillaceous earths exert a very slow action upon bodies; but when the earths are porous and light, the bodies then dry very speedily. The several principles of bodies absorbed by the earth, or carried by the vapours, are dispersed through a great space, imbibed by the roots of vegetables, and gradually decomposed. This is what passes in burying-grounds in the open air; but it is very far from being applicable to the sepulchres which are made in churches and covered places. Here is neither water nor vegetation; and consequently no cause which can carry away, dissolve, or change the nature of the animal fluids: and I cannot but applaud the wisdom of government, which has prohibited the burying in churches; a practice which was once a subject of horror and infection.

The accidents which have happened at the opening of graves and vaults are but too numerous, to render any apology necessary for our speaking a few words respecting the method of preventing them.

The decomposition of a body in the bowels of the earth can never be dangerous, provided it be buried at a sufficient depth, and that the grave be not opened before its entire and complete decomposition. The depth of the grave ought to be such that the external air cannot penetrate it; that the juices with which the earth is impregnated may not be conveyed to its surface; and that the exhalations, vapours, or gases, which are developed or formed by decomposition, should not be capable of forcing the earthy covering which detains them. The nature of the earth in which the grave is dug, influences all its effects. If the stratum which covers the body be argillaceous, the depth of the grave may be less, as this earth difficultly affords a passage to gas and vapour; but in general it is admitted to be necessary that bodies should be buried at the depth of five feet, to prevent all these unhappy accidents. It is likewise necessary to attend to the circumstance, that a grave ought not to be opened before the complete decomposition of the body. This decomposition, according to Mr. Petit, is not perfect until the expiration of three years, in graves of four feet depth; or four years, when they are six feet deep. This term affords many varieties, according to the nature of the earth, and the constitution of the subjects buried in it; but we may consider it as a medium. The pernicious custom which allows a single grave to families more or less numerous, ought therefore to be suppressed; for in this case the same grave may be opened before the time prescribed. These are abuses which ought to occupy the attention of government; and it is time that the vanity of individuals should be sacrificed to the public safety. It is likewise necessary to prohibit burying in vaults, and even in coffins. In the first case, the principles of the bodies are spread into the air, and infect it; in the second, their decomposition is slower and less perfect.

If these precautions be neglected; if the dead bodies be heaped together in too confined a space; if the earth be not proper to absorb the juices, and decompose them;

if the grave be opened before the entire decomposition of the body—unhappy accidents will, no doubt, be produced; and these accidents are but too common in great towns where every wise precaution is neglected. An instance of this happened when the ground of the church of St. Benoit at Paris was dug up a few years ago: a nauseous vapour was emitted, and several of the neighbours were affected by it. The earth which was taken out of this grave was unctuous, viscid, and emitted an infectious smell. Messrs. Maret and Navier have left us several similar observations.

Concerning Mineral Waters.

THE name of Mineral Water is given to any water whatever which is sufficiently loaded with foreign principles to produce an effect upon the human body, different from that which is produced by the waters commonly used for drink.

Men, doubtless, were not long in attending to the differences of waters. Our ancestors appear even to have been more strictly attentive than ourselves to procure wholesome drink. It was almost always the nature of the water which determined their preference in the situation of towns, the choice of habitations, and consequently the union of citizens. The smell, the taste, and more especially the effects of waters upon the animal economy, have been thought sufficient, during a long time, to determine their nature. We may see, in the writings of Hippocrates, how much observation and genius are capable of performing in subjects of this nature. This great man, of whom it would afford but a very imperfect idea to consider him merely as the Father of Medicine, was so well acquainted with the influence of water upon the human body, that he affirms that the mere quality

of their usual drink is capable of modifying and produc-
ing a difference between men; and he recommends to
young physicians to attend more particularly to the na-
ture of the waters their patients ought to use. We see
the Romans, who were frequently under the necessity of
settling in parched climates, spared no exertions to pro-
cure wholesome water to their colonies. The famous
aqueduct which carried the water of Uzes to Nismes, is
an unequivocal proof of this; and we still possess several
mineral springs at which they formed colonies, for the ad-
vantage of the baths.

It was not till near the seventeenth century that the ap-
plication of chemical methods to the examination of wa-
ters was first made. We are indebted to the present re-
volution of chemistry for the degree of perfection to
which this analysis has been carried.

The analysis of waters appears to me to be necessary,
in order—

1. That we may not make use of any water for drink
but such as is wholesome.

2. That we may become acquainted with those which
possess medicinal virtues, and apply them to the uses to
which they are suited.

3. To appropriate to the different works or manufacto-
ries that kind of water, which is the best calculated for
their respective purposes.

4. To correct impure waters, or such as are either im-
pregnated with any noxious principle, or charged with any
salt.

5. To imitate the known mineral waters, in all places
and at all times.

The analysis of mineral waters is one of the most diffi-
cult problems of Chemistry. In order to make a per-
fect analysis, it is necessary to be aware of all the distinct-
ive characters of the substances which may be held in
solution in any water. The operator must be acquainted
with the means of separating from an almost insensible
residue the different substances which compose it. He
must be able to appreciate the nature and quantity of the
products which are carried off by evaporation; and like-
wise to ascertain whether certain compounds are not form-

ed by the operations of his analysis, while others may be decomposed.

The substances contained in waters are held either in suspension or in solution.

1. Those substances which are capable of being suspended in waters are clay, silex in a state of division, calcareous earth, magnesia, &c.*

Those which are soluble are, pure air, the carbonic acid, pure or compound alkalis, lime, magnesia, the sulphates, the muriates, the extractive matter of plants, hepatic gas, &c. The most ancient, the most general, and the most simple division of mineral waters, is that which distinguishes them into cold waters, and hot or thermal waters, accordingly as their temperature is the same, or exceeds that of common water.

A division founded on the several qualities of these waters, will arrange them in four classes.

I. Acidulous or Gaseous Waters.—These are known by their penetrating taste; the facility with which they boil; the disengagement of bubbles by simple agitation, or even by mere standing; the property of reddening the tincture of turnsol; the precipitating lime-water, &c.

They are either cold or hot. The first are those of Seltz, of Chateldon, of Vals, of Perols, &c. The second are those of Vichi, of Montd'or, of Chatelguyon, &c.

II. Saline Waters, properly so called.—These are characterised by their saline taste, which is modified according to the nature of the salts they contain. The salts most generally found in waters are, the muriate of magnesia, the sulphates of soda, of lime, &c. Our waters of Balaruc, of Yeuset, &c. are of this nature.

III. Sulphureous Waters. These waters have long been considered as holding sulphur in solution. Messrs. Venel and Monnet opposed this assertion. Bergmann has proved that most of these waters are merely impregnated with hepatic gas. It appears, however, that there are some which hold true liver of sulphur in solution,

* Silex is soluble in some waters, as in those of Carlsbad in Bohemia, and Geyser in Iceland.—*Am. Ed.*

such as those of Bareges and of Cotteret ; whereas
the waters of Aix la Chappelle, Montmorency, &c. are
of the nature of those mentioned by Bergmann. We
may, with Mr. De Fourcroy, call the first by the name of
Hepatic Waters, and the latter by the name of Hepatized
Waters.

This class is known by the smell of rotten eggs which
they emit.

IV. Martial Waters.—These have the property of ex-
hibiting a blue colour by the solution of prussiate of lime :
they have besides a very evident astringent taste. The
iron is held in solution either by the carbonic or the sul-
phuric acid. In the first case the acid is either in excess,
and the water has a penetrating subacid taste, as the wa-
ters of Bussang, Spa, Pyrmont, Pougue, &c. ; or the
acid is not in excess, and consequently the waters are not
acidulous ; such are the waters of Forges, Condé, Aumale,
&c. Sometimes the iron is combined with the sulphuric
acid, and the water holds in solution a true sulphate of
iron. Mr. Opoix admits this salt in the waters of Pro-
vins ; and those of Rougne near Alais are almost satu-
rated with it. Mineral waters of this quality are frequently
found in the vicinity of strata of pyrites. There are se-
veral near Amalou, and in the diocese of Uzes.*

There are some waters which may be placed indiscri-
minately in several of the classes. Thus, for example,
there are saline waters which may be confounded with ga-

* The mineral waters of the United States, may be divided into
the acidulous, the hepatic or sulphureous, and the chalybeate.

The principal ingredients of the Balls-town and Saratoga waters,
in the state of New-York, are carbonic acid gas, sulphate and car-
bonate of iron and lime. The spring of Harrowgate in Pennsyl-
vania, that in the town of Greenbush, county of Rensaeller, New-
York, the two in Greenbriar, and Monroe county, Virginia, and
the one on the eastern side of the Paris mountain, South-Carolina,
are impregnated with sulphurated hydrogene gas, or hydrogene gas
holding sulphur in solution.

The yellow spring about twenty-nine miles west of Philadelphia,
and the one near Bristol, Pennsylvania, are slightly impregnated
with iron.

There are also warm springs in the state of Virginia, the tem-
perature of which are, from 102° to 108° of Fahrenheit's thermo-
meter.—*Am. Ed.*

seous waters, because air is constantly disengaged from them. The waters of Balaruc are of this kind.

We do not comprehend among mineral waters those which suffer gas to escape through them, without communicating any characteristic property; such as the burning spring of Dauphiny, &c.

When the nature of any water is ascertained, its analysis may be proceeded upon by the union of chemical and physical means. I call those methods physical, which are used to ascertain certain properties of water without decomposing them. These methods are, for the most part, such as may be carried into effect at the spring itself. The appearance, the smell, and the taste afford indications by no means to be neglected.

The limpidity of any water indicates its purity, or at least the accurate solution of the foreign principles it may contain; an imperfect transparency denotes that foreign substances are suspended. Good water has no smell : the smell of rotten eggs denotes liver of sulphur, or hepatic gas; a subtile and penetrating smell is proper to acidulous waters; and a fetid smell characterizes stagnant waters.

The bitterness of waters in general depends on neutral salts. Lime, and the sulphates, give them an austere taste.

It is likewise of importance to ascertain the specific gravity of the water, which may be done either by means of the areometer, or by the comparison of its weight with that of an equal volume of distilled water.

The degree of heat must likewise be taken by means of a good mercurial thermometer. Thermometers made with spirits of wine ought to be rejected; because the dilatation, after the thirty-second degree of Reaumur, is extreme, and no longer corresponds with the temperature of the water. It is interesting to calculate the time which the water requires to become cool, in comparison with distilled water raised to the same degree of temperature. Notice must likewise be taken whether any substance exhales, or is precipitated by the cooling.

The observer ought likewise to enquire whether rains, dry seasons, or other variations of the atmosphere, have any influence on the temperature or quantity of water of

the spring. If these causes act upon the spring, its vir-
tue cannot but vary exceedingly. This is the cause why
certain mineral waters are more highly charged with these
principles in one year than in another ; and hence also it
arises that certain waters produce wonderful effects in
some years, though in other seasons their effects are tri-
fling. The celebrated De Haen, who analysed for seve-
ral successive years all the waters in the neighbourhood
of Vienna, never found them to contain the same princi-
ples in the same proportion. It would therefore be an in-
teresting circumstance, if, at the time of taking up or
bottling of these waters, a skilful physician were to ana-
lyse them, and publish the result.

After these preliminary examinations have been made
at the spring, further experiments must be made accord-
ing to the methods of chemistry. These experiments
ought to be performed at the spring itself : but if
this cannot be done, new bottles may be filled with the
water ; and, after closing them very accurately, they may
be carried to the laboratory of the chemist, who must
proceed to examine them by re-agents, and by the me-
thod of analysis.

I. The substances contained in water are decomposed
by means of re-agents ; and the new combinations or pre-
cipitates which are formed, immediately point out the na-
ture of the principles contained in the waters. The most
efficacious and the only necessary re-agents are the follow-
ing :

1. Tincture of turnsol becomes red by its mixture
with acidulous waters.

2. Prussiate of lime, and that of ferruginous potash
not saturated, precipitate the iron contained in a mineral
water of a blue colour.

3. The very concentrated sulphuric acid decomposes
most neutral salts ; and forms with their bases salts very
well known, and easily distinguished.

4. The oxalic acid, or acid of sugar, disengages lime
from all its combinations, and forms with it an insoluble
salt.

The oxalate of ammoniac produces a more speedy ef-
fect ; for, by adding a few crystals of this salt to water

charged with any calcareous salt, an insoluble precipitate is instantly formed.

5. Ammoniac or volatile alkali affords a beautiful blue colour with the solutions of copper. When this alkali is very pure, it does not precipitate the calcareous salt, but decomposes the magnesian only. In order to have it in a highly caustic state, a syphon may be plunged in the mineral water, and ammoniacal gas or alkaline air passed through it. The water ought to be kept from the contact of the atmosphere, which otherwise might occasion a precipitation by virtue of its carbonic acid.

6. Lime water precipitates magnesia; and it likewise precipitates the iron from a solution of sulphate of iron.

7. The muriate of barytes detects the smallest particle of sulphuric salts, by the regeneration of ponderous spar, which is insoluble, and falls down.

8. Alcohol is a good re-agent, on account of its affinity with water.

The nitrates of silver and of mercury may likewise be employed to decompose sulphuric or muriatic salts.

II. These re-agents, indeed, point out the nature of the substances contained in any water; but they do not exhibit their accurate proportions. For this purpose we are obliged to have recourse to other means.

There are two things to be considered in the analysis of any water : 1. The volatile principles. 2. The fixed principles.

1. The volatile principles are carbonic acid gas and hepatic gas. The proportion of carbonic acid may be ascertained by various processes. The first, which has been used by Mr. Venel, consists in half filling a bottle with the gaseous water intended to be analysed. A bladder is then to be tied upon the neck of the bottle, and the water agitated. The air which is disengaged inflates the bladder; and by that indication an estimate may be made of its quantity. This process is not accurate; because agitation is not sufficient to disengage the whole of the carbonic acid. Neither is the evaporation of the water in the pneumato-chemical apparatus much more exact; because the water which rises with the air combines again with it, and the gaseous product consists only of a part of the gas contained in the water. The precipitation by

lime-water appears to me to be the most accurate process.
Lime-water is poured into a determinate quantity of the
water, until it ceases to cause any precipitate. This pre-
cipitate being very accurately weighed, $\frac{10}{32}$ parts of the
whole must be deducted for the proportion in which wa-
ter and earth enter into it; and the remainder is the acid
contained in this carbonate of lime.

Hepatic gas may be precipitated by the very concen-
trated nitric acid, according to the experiments of Berg-
mann.

The oxigenated muriatic acid has been proposed by
Scheele; and Mr. De Fourcroy has pointed out the sul-
phureous acid, the oxides of lead, and other re-agents,
to precipitate the small quantity of sulphur held in solu-
tion in hepatic gas.

2. Evaporation is commonly used to ascertain the na-
ture of the fixed principles contained in any mineral wa-
ter. Vessels of earth or porcelain are the only kind suit-
able to this purpose.

The evaporation must be moderate; for strong ebulli-
tion volatilizes some substances, and decomposes others.
In proportion as the evaporation proceeds, precipitates are
afforded, which Mr. Bouldue proposes to take out as they
are formed. The celebrated Bergmann advises evapora-
tion to dryness, and to analyse the residue in the follow-
ing manner:

1. This residue must be put into a small phial, and
strongly agitated with alcohol; after which the fluid must
be filtrated.

2. Upon the residue pour eight times its weight of cold
distilled water; agitate this, and filter the fluid, after
standing several hours.

3. Lastly, the residue must be boiled for a quarter of an
hour in five or six hundred parts of distilled water, which
fluid must be separated by filtration.

4. The residue, which is neither soluble in water nor
in alcohol, must then be moistened, and exposed for se-
veral days to the sun: by this treatment the iron which it
may contain, rusts. It must then be digested in distilled
vinegar, which dissolves lime and magnesia; and this so-
lution, evaporated to dryness, affords either an earthy salt
in filaments which are not deliquescent, or a deliquescent

salt; which last has magnesia for its base. The insoluble residue contains iron and clay, which are to be dissolved in the muriatic acid. The iron is first to be precipitated by the prussiate of lime; and afterwards the clay by another alkali.

The salts which the alcohol has dissolved, are the muriates of magnesia and of lime. They are easily known by decomposing them by the sulphuric acid.

With respect to the salts dissolved in the cold water, they must be slowly crystallized; and their form, and other obvious qualities, will shew what they are.

The solution by boiling water contains nothing but sulphate of lime.

When the analysis of any water has been well made, the synthesis becomes easy; and the composition or perfect imitation of mineral waters is no longer a problem insoluble to chemists. What, in fact, is a mineral water? It is rain water, which, filtering through the mountains, becomes impregnated with the various soluble principles it meets with. Why, therefore, when once we know the nature of these principles, can it not be possible to dissolve them in common water, and to do that which nature itself does? Nature is inimitable only in its vital operations; we may imitate its effects perfectly in all other processes: we may even do better; for we can at pleasure vary the temperature and the proportions of the constituent parts. The machine of Nooth, improved by Parker, may be made use of to compose any gaseous mineral water, whether acidulous or hepatic; and nothing is more easy than to imitate such waters as contain only fixed principles.

THE END

INDEX.

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